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ELECTRONICS ENGINEERING

OF CANADA

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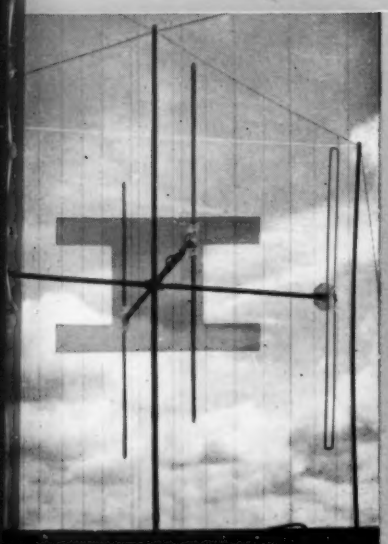

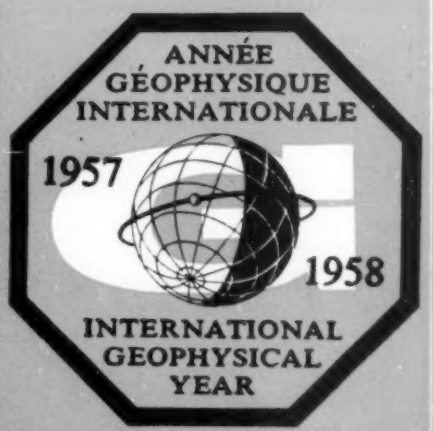

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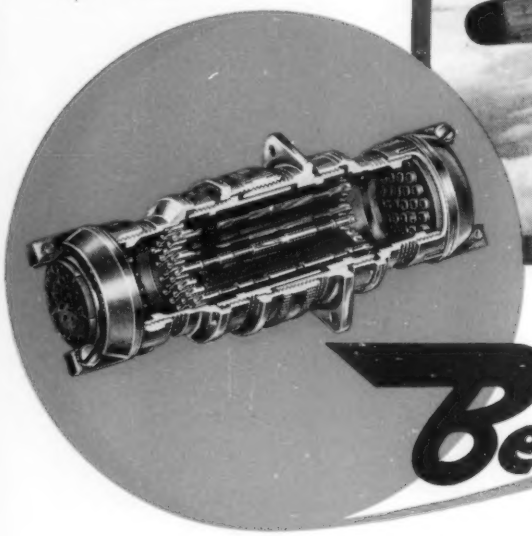

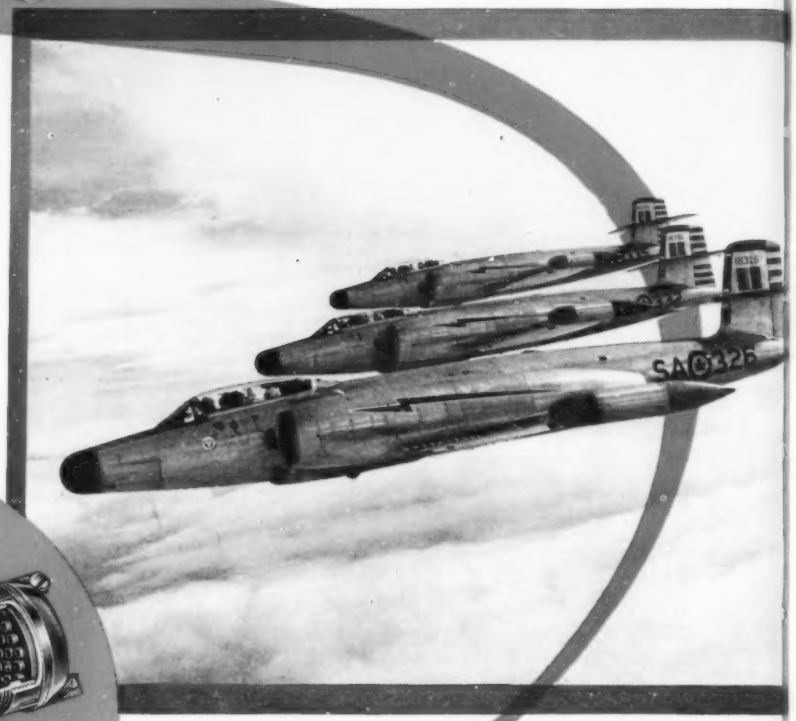

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july 1957

volume one, number 3

ELECTRONICS ENGINEERING

OF CANADA

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*** our cover design** *Canada is symbolized by the auroral radar antennas (left) and the Aurora Borealis (right). Centre is the official symbol of IGY*

UNI-RING offers a tremendous saving in installation time over any previous method of tapping or terminating shielded or coaxial cable. As the inner ring slides under the shielded braid, the tap wire is held between the braid and the outer ring. Single or multiple taps, from either the front or back of the connector, can be accommodated . . . A single crimp, using the same basic HYTOOLS used for installing HYRINGS, completes the uniform, secure, and insulated assembly.

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Yen & MacRae

Starting in Halifax, where he was born, **Donald A. MacRae,** one of the authors of "Star gazing with Electronics," has moved around the United States until he finally came back to Canada in 1953, becoming Professor of Astronomy at the David Dunlap Observatory, University of Toronto.

He took a B.A. at the University of Toronto in mathematics and physics and then a Ph.D. at Harvard in 1942. He was at the University of Pennsylvania and Cornell University from 1941-43. Dr. MacRae worked on the Manhattan Project, Oak Ridge, Tennessee, to 1945 and was at the Case Institute of Technology, Cleveland, Ohio, from then until he came to Toronto.

Co-author of the article, **Jui Lin Yen** came to Canada in 1948 after attending the Chao Tung University in China for a B.Sc. He took an MASc at the University of Toronto in 1950 and a Ph.D. in 1953 for work on electromagnetic theory. His active research is on microwave theory and system theory with current work on radio astronomy. Hobbies? A new M.G. and good music.

Until the end of the International Geophysical Year **Allen G. McNamara** (Radar probes the aurora) is going to be particularly busy. He is concerned with the radar and optical program of auroral observations in Canada. Coming from Regina, Saskatchewan, he went to the University of Saskatchewan to take a B.Sc in engineering physics and an M.Sc in physics. Then came an A.M. from the University of Michigan and a Ph. D from the U of S where he did research work on the reflection of radio waves from the aurora.

Now he is with the National Research Council in Ottawa doing fundamental research on the physics of the aurora. He is also involved in "radio reflections from meteors and investigations into backward and forward scatter."

McNamara

Burgess

Ronald E. Burgess (Thermal and high field effects in semiconductor devices) spent 16 months on a tour of duty in the U. S. and Canada as radio physicist with the United Kingdom Scientific Mission in 1948-49. He is now a professor at the University of British Columbia.

After graduating in physics and mathematics with first-class honours from the University of London he did research in a number of fields at the Radio Research Station in England, devoting particular attention to antenna and circuit theory, signal-to-noise problems, fluctuation theory and semiconductors.

At the U of BC he has set up a program of research on physical electronics under the auspices of DRB. He is the American editor of the annual review "Progress in semiconductors," a Senior Member of the IRE and a Member of the Amer. Phys. Soc.

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Aviation Electric appoint two division heads

Taylor

Murray

Moffat

Solandt

Two new staff appointments have been made by Aviation Electric Ltd., of Montreal, Que. Director, Engineering Products Division, is D. R. Taylor who has been in the aviation industry since he graduated from McGill University. He joined Aviation Electric Ltd. in 1952 and was promoted to sales manager in 1956. In his new position he is responsible for all AEL sales and service, engineering and manufacturing activities.

Second appointment is that of A. Lavendel as Director, Overhaul Division. In 1940, Mr. Lavendel was a civilian instructor with the RCAF and joined Aviation Electric Ltd. in 1944, where he has served as field service liaison, service engineer, sales and service engineer and manager of the Overhaul Division.

Murray heads Dominion Council of Engineers

C. N. Murray, P.Eng., of Sydney, N.S., was elected new president of the Dominion Council of Professional Engineers at their three-day annual meeting in Halifax. He succeeds E. J. Durnin, P.Eng., of Regina.

The 30,000-member Council represents the engineering associations of all ten Canadian provinces and the Yukon Territories. Mr. Murray is general superintendent of Dominion Iron and Steel Ltd.

New data centre for CNR

William P. Moffat has taken over the new position of co-ordinator of data processing for the Canadian National Railways in Montreal. He will be responsible for the operation and future expansion of CNR's integrated data processing system and computor centre.

A native of Winnipeg, Mr. Moffat is a graduate of the Royal Military College, a civil engineer and a wartime naval commander. He joined CNR in 1936 in the bureau of economics. He became chief of research in 1955.

CNR also announce the appointment of Dr. Omond M. Solandt as vice-president of research and development, following the retirement of Starr W. Fairweather. For more than 40 years Mr. Fairweather had been associated with railroad and industrial development projects in Canada.

Dr. Solandt, also born in Winnipeg, is a former chairman of the Defence Research Board.

Manager of Hoover electronic dept.

The Hoover Company Ltd., have appointed G. F. Godfrey as manager of the Electronic Component and Equipment Department. Mr. Godfrey comes from Saskatoon and went to the University of British Columbia where he took a BASc in electrical engineering. He later took an M.Eng. at McGill. Before joining Hoover he was Manager, Defence Contracts Department of Addison Industries Ltd., Toronto.

His department will handle all electronic equipment sales including Defence Department requirements for rotating electrical apparatus. Close liaison will be maintained with Hoover companies in the U. S. which operate in the general fields of digital data processing, telemetering and special instrumentation.

Development group at National Carbon

New appointments to the Development Organization of National Carbon Company, Division of Union Carbide Canada Ltd., have been announced. W. A. Dimma, P.Eng., is appointed manager of the Development Organization, W. L. Kennedy, BSc, and

Godfrey

Dimma

H. L. Tipple, P.Eng., will be responsible for the development of new products while H. M. Brown, P.Eng., Laboratory Director, continues in charge of existing product and process development.

The purpose of this group is to investigate and develop new products to be manufactured or marketed by National Carbon.

Morrison will handle CGE marketing

Charles A. Morrison, formerly general manager of Canadian General Electric's wholesale department, will be concerned with broad company marketing problems, working in close co-operation with the nine operating departments and departmental sales organizations. Mr. Morrison has over 25 years of marketing experience in all the company's major product lines.

Walter G. Ward succeeds Mr. Morrison as general manager of the wholesale department. Previously Mr. Ward was manager, induction motors, at Peterborough.

Appointments in brief

Two Canadian Westinghouse Company general managers have been elected to vice-president posts. They are Edward E. Orlando, general manager of the District Apparatus Division and John A. Campanaro, Project Development Group general manager.

One of a number of appointments announced by Atlas Radio Corporation Ltd., Toronto, is the promotion of F. Harris, general sales manager, to General Manager. He started with Atlas Radio in 1941 after graduating from the University of Toronto.

New personnel appointments by the Shakeproof-Fastex Division of Canada Illinois Tools Ltd., Toronto are: G. McIlwain sales manager; J. Harris, plant superintendent; D. Hart, engineer and C. Wilson, production control manager.

Canadian Line Materials Ltd., have appointed R. G. Mason as sales engineering manager in Calgary, Alberta. Mr. Mason is a BSc graduate of the University of Alberta.

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High sensitivity, dc to 300 KC

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Sweeps 1 usec/cm to 12.5 sec/cm

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This totally new production and laboratory instrument obsoletes previous concepts of oscilloscope convenience, usefulness and reliability.

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Triggering: Internal, line voltage or external 0.5 v or more. Pos. or neg. slope, + 30 to —30 v trigger range.
Preset Trigger: Optimum setting for automatic stable triggering.
Amplitude Calibration: 1 KC square wave. 5% accuracy.
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also offers -*hp*- 150A High Frequency Oscilloscope, dc to 10 MC, sweeps 0.02 μsec/cm to 15 sec/cm. Rise time 0.035 μsec.

Four Decca Navigator chains for the East coast

Four chains of ground stations, giving radio position-fixing for shipping, are being installed on Canada's eastern seaboard. The stations—the Decca Navigator system—are being located on the south coast of Newfoundland, near Gander, Newfoundland and in the vicinities of Halifax and Quebec.

Each system consists of a master transmitting station and three slave stations located approximately 80 miles apart and each giving continuous navigation coverage to areas of about 200,000 square miles. The systems are being installed by the Decca Navigator Co. in co-operation with Computing Devices of Canada Ltd., of Ottawa, the Canadian licensees.

The system on the south coast of Newfoundland is already operating and evaluation tests are under way. A chain of four stations continuously transmits radio signals which can be picked up and plotted from ground level to all altitudes.

Canadians at Chicago distributors' show

About 180 Canadians registered at the 1957 Electronic Parts Distributors' Show in Chicago. The annual Canadian luncheon had C. G. "Jerry" Pointon, chairman of Canadian Electronic Sales Representatives, as its chairman and was addressed by D. Lou Harris, of Atlas Radio Corporation Ltd., Toronto. Mr. Harris was introduced by A. C. Simmonds, of A. C. Simmonds and Sons Ltd., Toronto.

At the annual breakfast meeting E. G. Hill, of Antiference (Canada) Ltd., Toronto, was appointed secretary of Canadian Electronic Sales Representatives in succession to John T. Rochford who is now full-time secretary-treasurer of the Canadian Electronic Wholesalers' Association.

New plant for Burndy Canada Ltd.

Burndy Canada Ltd. expect their new plant, located at Birchmount and Burcana in Scarborough, Ontario, to be in full production immediately following the Civic Holiday (August 5).

The 75,000 sq. ft. factory and office building will be devoted to the engineering, manufacture and sale of the great variety of Burndy Electrical Connectors. "It represents a two and one-half times increase of the company's existing facilities," says General Manager F. H. McLenaghan, who also forecasts an increase in the activities of Burndy's Omaton Division, which produces smaller connectors for use by the electrical and electronic industries.

Automatic Electric expand plant

Construction work on the million and a half dollar expansion of the Automatic Electric (Canada) Limited plant has begun in Brockville, Ontario.

The factory, which manufactures communication equipment and electrical control apparatus, will be almost doubling its present floor space, from 125,000 to 211,000 sq. ft.

Mr. C. R. Hughes, president of the company, says, "Work should be completed at the end of 1957."

IBM '650' installed by Du Pont

A "Tape 650" computer, manufactured by International Business Machines Company Ltd., in Toronto, has been installed by Du Pont of Canada in its Montreal head office.

The computer consists of ten units and is the first of this type assembled in Canada. It differs from other medium-sized computers in that it makes use of magnetic tapes for "memory" storage. The only other magnetic tape machine in Canada is the larger type 705 computer recently installed by the CPR.

On the '650' a reel of magnetic tape will hold up to 5,000,000 characters which can be written on or read off the tape at the rate of 15,000 characters a second. Initially the computer will be used for accounting and other business data applications.

TCC factory at 50 Bertal Rd., Toronto

T.C.C. Canada (The Telegraph Condenser Co. (Canada) Ltd.) now has an office at 44 Wellington St. E., Toronto, Ontario, and a factory, also in Toronto. TCC products were formerly handled by exclusive agents, The Glendon Company Ltd.

The parent company, TCC is the largest manufacturer of fixed capacitors outside the U. S. and is affiliated with British Insulated Callenders Cable Group and British Dielectric Research Ltd.

News from here and there

Radionics Ltd., of Montreal, P.Q., are now Canadian representatives for WacLine Inc., of Dayton, Ohio. WacLine manufacture meters, speed drives, tachometer generators and a line of dummy loads.

The Reflectone Corporation, Stamford, Conn., manufacturers of precision components, simulators and training devices, have appointed MEL Sales of Arnprior, Ontario, as their Canadian representative.

Algoma Steel Corporation Ltd., Sault Ste. Marie, have placed a $3,000,000 order with Canadian Westinghouse Co. Ltd., for complete electrical installations in their new plant, including a Westinghouse Prodac (programed digital automatic control) unit.

Raytheon Canada Limited state they are designing a "considerable portion" of the equipment for long range surveillance radars being installed at 15 air centres for Canada's Department of Transport. All the equipment they design in Canada is being manufactured by Raytheon Canada Ltd. in Canada.

New plant of Muirhead Instruments Ltd., at Stratford, Ontario

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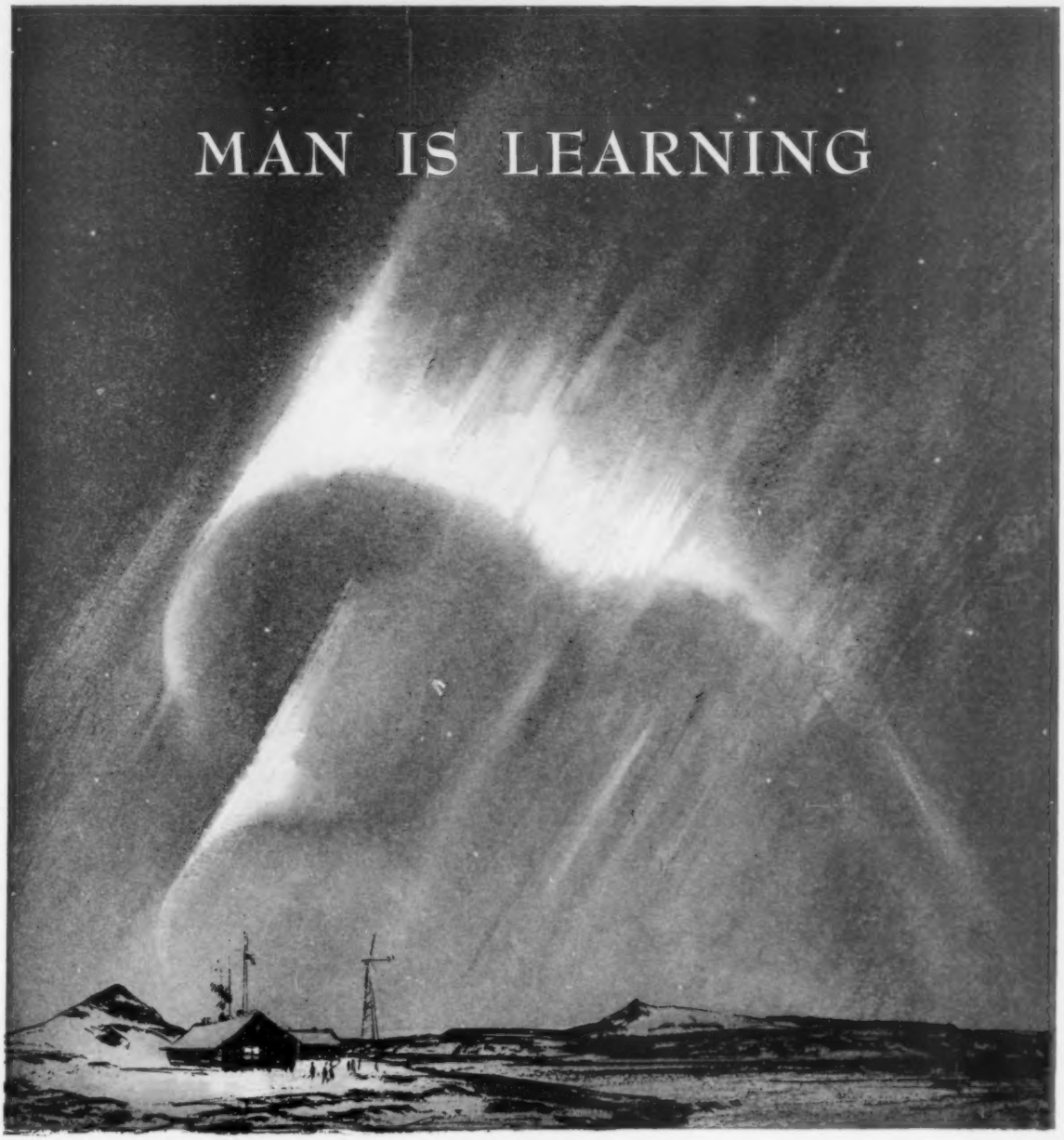

MAN's unceasing quest for more knowledge of space and his world will continue with new vigour during the International Geophysical Year. Of the 43 countries uniting to make simultaneous observations, Canada's contribution will be significant for its studies of the ionosphere and of changes in the earth's magnetic field. Canadian Applied Research Limited is honoured to work with the Canadian scientists. Such new and unique instruments as the Auroral Recorder, the Stationary Magnetometer and a recording camera were engineered and produced for the project by Canada's leading instrumentation firm.

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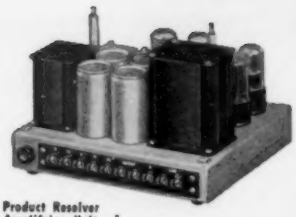
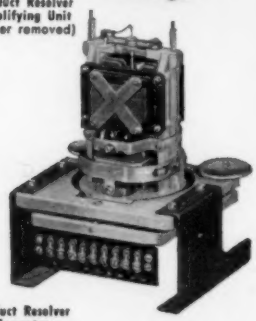


Product Resolver Amplifying Unit (cover removed)



Product Resolver Converter (cover removed)

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Performance and application features:

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- Telephone Type Construction. Easy inspection and maintenance.
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- Complete Instruction Material.

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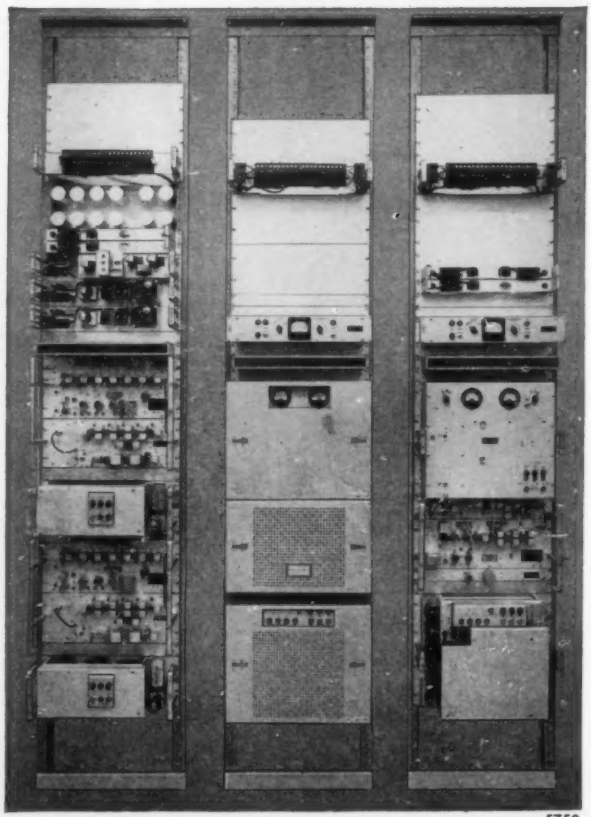

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ELECTRONICS ENGINEERING
OF CANADA

After all, "Professional engineers are human"

In Canada the base-line status of the professional engineer is recognized by the letters P. Eng. which he appends to his name. But the "forward look" in the engineering field, for both engineers and management, is that these letters should have a meaning that continues to increase in significance.

The Professional Engineers Act of Ontario covers the point to which we refer. Section 4 of the Act states in part:

> "The Council may pass by-laws or amendments to existing by-laws for (m) instituting and providing means for increasing the knowledge and skill of professional engineers, for advancing their status and well-being, and for maintaining a high standard of professional ethics among them."

Direct contributions toward the implementation of the first part of this paragraph are, of course, being made by organizations such as The Engineering Institute of Canada and The Institute of Radio Engineers in arranging regular meetings on technical subjects and in publishing journals containing news and papers of engineering and scientific interest.

As far as the second and third clauses are concerned, their fulfilment appears to be a joint responsibility of management and of the professional engineers themselves. The conception of joint action was brought out in a very clear way in the bulletin prepared and distributed by the A.P.E.O. earlier this year, entitled "Professional Recognition — a report to Management and Engineers." Presented in parallel columns were two excellently written statements of the ways in which management and professional engineers might play their respective roles.

The final paragraphs of the two parts of the report read as follows:

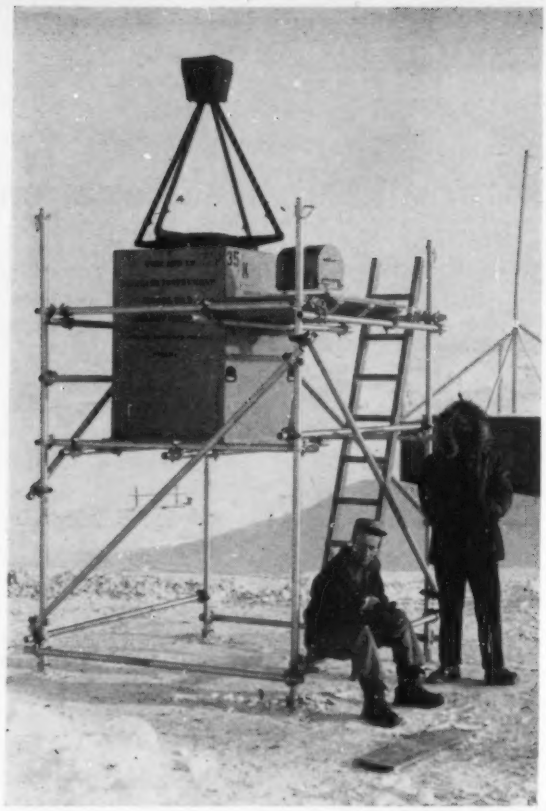
To management — "Professional engineers are human. They appreciate an opportunity to better themselves and to do a better job. To this end management should give the professional engineer an adequate chance to express himself. It should show him that it wants him to be the best in his field — indeed, it expects him to be the best in his field."

To the Professional Engineer — "Above all, remember that the broad view is important to full understanding and that with understanding comes professional stature. As you attain professional stature you are doing your part to create the ideal 'climate' in your relationship with management."

These two extracts seem to us to put the whole question of the implementation of Section 4, subsection 1, paragraph (m) of the Act in a nutshell, and we commend them to our readers. They elevate what might otherwise be a dry piece of legislation into a simple statement of human and business relationships which, if regarded as a "gospel" by both parties concerned, will not only benefit our industry and its professional engineering employees, but the country as a whole.

THE EDITOR

The International Geophysical Year has just started. Canada's main contribution will be in studies of the aurora but a tremendous amount of work is being done in nearly all the IGY disciplines. In this review of the IGY program the emphasis is on Canada's effort and the electronic equipment being used.



Canada's farthest north station for the IGY program. Two officers and an all-sky camera at Alert, on latitude 82°5′.

Canada has a big part to play in IGY as

Science takes a new look at the world

KENNETH W. LINES, MANAGING EDITOR

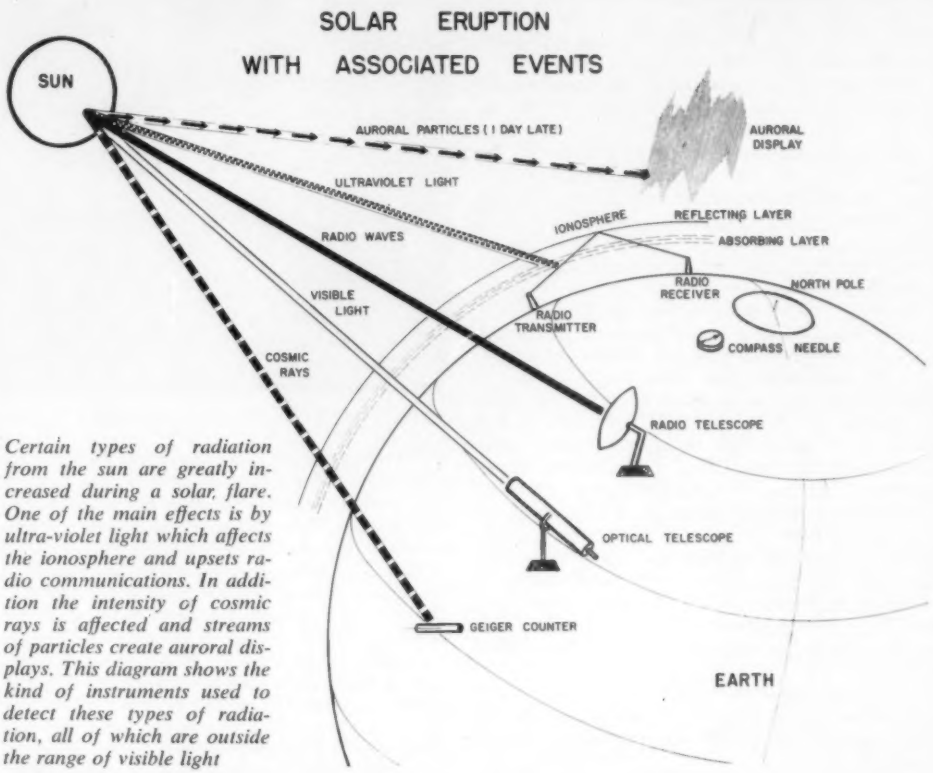
Every branch of science will benefit, in some way or another, as the result of the work being done during the International Geophysical Year which began, officially, on July 1. In turn, there is hardly any section of the intensive scientific crash program of IGY that does not owe a tremendous amount to electronics.

Most of the equipment being used in the IGY program will include electronic instruments of some kind or another. Some instruments will be going down into the mines, others will be carried on the dog sleds and snowmobiles across the Arctic and Antarctic wastes. Some will be going to the deepest part of the seabed, while others will be making sure that cameras and radar telescopes keep a constant watch on the sky during the hours of twilight and darkness. Some of the most publicized electronic instruments will be in the artificial satellites which are being launched by the United States and Russia and will circle the earth in orbits between 300 and 800 miles high, transmitting back information on temperature, pressure, cosmic ray bombardment, light intensities and magnetic fields.

The idea of the IGY was put forward at an informal meeting of scientists in Washington in 1950. The period of July 1957 to December 1958 was suggested because it was one of the sunspot maximum. At the same time it tied in with previous work on International Geophysics in that it was 25 years after the second International Polar Year. The First International Polar Year took place in 1882-1883 and was a co-operative undertaking by many nations for the purpose of investigating geophysical phenomena particularly in the northern polar regions. The second IPY in 1932-33, a year of sunspot minimum, carried on the investigations and resulted in a large extension and consolidation of geophysical knowledge.

Fifty-five nations will be taking part in this new IGY enterprise and the cost to them is expected to run to over $500 million. In 14 different fields of learning scientists will investigate the earth, measuring such phenomena as the aurora, meteors, glaciers, the ionosphere, tides and currents, magnetism, cosmic rays, solar flares and sunspots. This eighteen-month period of intensive activity is expected to cover what would normally take at least 20 years in scientific research.

During IGY there will be several periods of particular



Certain types of radiation from the sun are greatly increased during a solar flare. One of the main effects is by ultra-violet light which affects the ionosphere and upsets radio communications. In addition the intensity of cosmic rays is affected and streams of particles create auroral displays. This diagram shows the kind of instruments used to detect these types of radiation, all of which are outside the range of visible light

interest and effort and there will also be a solar eclipse which will be seen in the south polar regions. Scientists who will be studying the related phenomena either caused or influenced by the sun's energy are expecting to gain a lot more knowledge from the period of sunspot maximum because it is then that unusual effects of the sun are more pronounced. At the same time the over-all concentrated attack on the earth and its surrounding atmosphere is expected to produce very good research results for two reasons. Firstly, measurements made in isolation, even at many points about the earth's surface, can never give a completely true picture. In the past, many of these individual measurements have been made but rarely has any attempt been made to correlate them on an international basis. Secondly, the forces themselves are complicated by other phenomena which, at the time the measurements are made, may not be taken into account. When an attack is made, as during IGY, on all the related phenomena, the final statistics on any one group of phenomena can take into account other natural results which may have a considerable effect on them.

The international program of IGY is co-ordinated by a committee formed by the Council of International Scientific Unions. Their headquarters are in Belgium under the direction of Dr. M. Nicolet who is secretary of the "Comite Special de l'Annee Geophysique Internationale (CSAGI)." Chairman of IGY is England's Prof. Sidney Chapman, leading world authority on magnetic forces. Dr. D. C. Rose of the Division of Pure Physics, National Research Council, Ottawa and a celebrated expert on cosmic rays, is chief co-ordinator of Canada's effort. The other members of the executive committee are Dr. C. S. Beals (Astrophysics) Dominion Observatory, Mr. F. T. Davies (Geophysics) Defense Research Board and Dr. D. W. R. McKinley (Radio Physics) National Research Council. The advisory committee for the program represents all government agencies and university departments engaged in earth sciences.

The Canadian scientific program is mainly in the fields of research which were active in Canada but which will be enhanced to fit into the International program. Since Canadian territory includes a large area which is important to the International program, efforts are being concentrated on measurements in Canada and not on sending expeditions to other countries. On the other hand, except for a comprehensive rocket firing program at Churchill by the United States, no other country is sending expeditions into Northern Canada.

The main work in Canada is being done as follows: Defense Research Board (ionosphere physics, solar activity, glaciology); Department of Mines & Technical Surveys (geomagnetism, solar activity, longitudes and latitudes, oceanography, seismology, gravity, meteor studies); Department of Transport, (ionosphere, telecommunications, meteorology); National Research Council (aurora and airglow, ionosphere, solar activity, cosmic rays, glaciology, meteors); Joint Committee on Oceanography (ocean tides, water levels, currents); University of Alberta (meteorology); Queen's University (ionosphere); University of Saskatchewan (geomagnetism, aurora, ionosphere); University of Toronto (solar activity, glaciology); and the University of Western Ontario (ionosphere).

Studies of the Aurora

It is expected that Canada's major contribution to IGY will be in the studies of the aurora. The work is being carried out jointly by Prof. B. W. Currie of the University of Saskatchewan and Dr. P. M. Millman of NRC. There will also be a study of meteor trails in the upper atmosphere, a field in which Dr. Millman and Dr. D. W. R. McKinley of NRC have already done a tremendous amount. The main question that it is hoped will be answered is "what is the size or extent of each aurora display, how long does it last, where does it move to, and how does its size or extent change as it moves?"

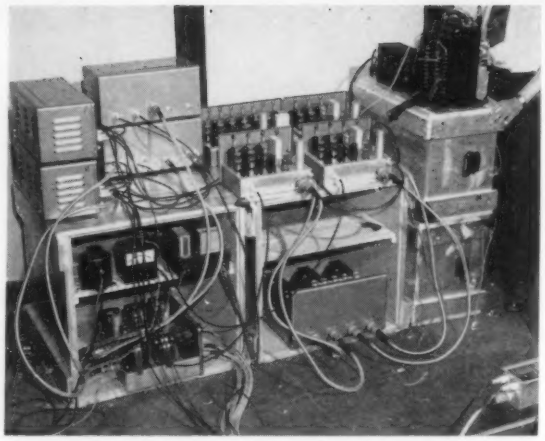
The aurora program will consist mainly of continuous observation of intensity, spectra and type at a group of stations extending through the auroral belt in northern Canada. The longer aurora line doubles with the Canadian weather stations near the 90 deg west meridian. Beginning at Alert (about 1,200 miles above the Arctic Circle) the auroral stations include Resolute Bay (700 miles to the south), Baker Lake (700 miles further south), and Fort Churchill (another 400 miles south). There is a second auroral chain in the west which begins at Norman Wells (in the latitude of Great Bear Lake) and includes Yellowknife, Uranium City, and Meanook (Central Alberta), ending at Victoria in British Columbia. Visual observers at these stations and hundreds of other points over Canada will watch the overhead sky all night and record what they see. As an auroral arc may extend 1,000 miles and move 500 miles, the work of these observers is obviously of great importance. In addition, there will be radar equipment which will measure the occurrence of the northern lights over wide areas.

Auroral radar has an omni-directional transmitter and the receiver takes in a quarter of the sky at a time. It takes 2 min to rotate through 360 deg stopping for 30 sec at every quarter.

Rose

Millman

A number of the stations will have all-sky cameras, which have been developed by NRC. The camera itself is mounted on long arms and pointed at a convex mirror which is capable of reflecting practically the whole area of visible sky. The camera can photograph continuously at given intervals—usually of about one minute duration—and with a program unit can be switched on automatically as dusk falls and switched on again when daylight comes. With 35 mm film the camera will take pictures and will also record the time of each exposure, for about 24 hours without attention. Other instruments will include intensity recorders. The auroral intensity recorder scans the sky from northern to southern horizon along a meridian in a period of five minutes. It picks up light from the aurora, measures it photo-electrically and translates the measurements into punched tape for subsequent handling by computers. From these measurements it will be possible to determine the exact height and strength of the aurora at any given time.



Test work on NRC cosmic ray equipment for IGY program

From the light recording photometers it is hoped to get a lot more information about night air glow which is a light shed down on the surface of the air from the upper atmosphere. The altitude of the upper air luminosity is known to be from 100 to 300 km but the exact altitude and vertical distribution has not been determined. The luminosity is diffuse and has no sharp features on which to attempt triangulations. Its spectrum is that of oxygen and nitrogen, the two abundant gases of the upper and lower atmosphere. The spectrum also shows the yellow lines of sodium but how the sodium gets into the upper atmosphere is not yet known.

Check on the Ionosphere

Canada will also be taking a major interest in the ionosphere. This envelope of rarified upper air from 50 to 250 miles above the earth surface, normally reflects radio waves but any unusual activity by the sun causes the ionosphere layers to be conductors rather than reflectors and this has serious effects, causing complete fade-outs, in radio reception around the world. Better knowledge of the ionosphere should show the best radio frequencies to be used during times of disturbance and should also suggest other radio channels which would by-pass troublesome areas. Radar is the main tool in studying the ionosphere. There are usually about 90 ionosphere stations in continuous operation over the earth. They are the standard vertical incidence pulse sounding stations but for the IGY program about 50 additional stations of the same type are planned and they will operate automatically and make multi-frequency recordings at set intervals, usually about every hour.

Movements, patchiness and other irregularities in the ionosphere are being investigated by multi-frequency soundings and by fixed frequency soundings by spaced receivers which make fading observations. Ionosphere recorders in Canada are at Ottawa, Resolute, Baker Lake, Churchill and Winnipeg. Additional recorders during IGY are being operated from Meanook, Yellowknife and Norman Wells. Equipment for measuring E-layer tides will be operated at Churchill and Ottawa. Equipment for measuring absorption is at Alert, Churchill and Baker Lake with transmitters and receivers at Resolute and Winnipeg.

Investigations are being made into scatter techniques, both backward and forward, and these are being carried out at frequencies of 35 and 50 megacycles by a transmitter at Yellowknife and receivers at Baker Lake, Churchill, The Pas, Saskatoon and Meanook. One of the men behind this part of the program is Dr. P. A. Forsyth, formerly of Saskatoon and now of the Defense Research

This map shows the location of the main observation stations in Canada during the International Geophysical Year

Board in Ottawa, has already done a lot of work on scattering from aurora displays and meteor trails. His experiments were among those that developed the technique of transmission from meteor trails—known under the code name of Janet. Research will also be made into a special kind of radio wave which occurs naturally in the earth's atmosphere. These waves, known as "whistlers," result from flashes of lightning and they are so low in frequency as to be directly audible through radio receviers. Whistlers follow the earth's magnetic lines of force and from a detailed study of them it is hoped to get more facts about ionization at very high levels and about the outer atmosphere which is now known to extend to at least 7,000 miles from the earth.

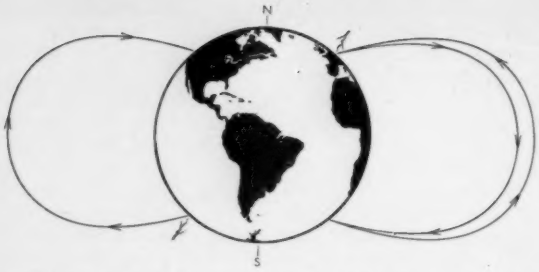
During IGY radar will keep a check on the meteors to determine the numbers encountered by the earth. Spectrographs can show what the meteors are made of—usually sodium, magnesium and iron and to obtain the meteor's flight, two stations operating together produce the necessary information. In Canada the meteor stations will operate at Meanook and Newbrook in Northern Alberta and at Springhill, near Ottawa. Hundreds of visual observers will also co-operate in counting meteors.

The influence of solar activity on radio waves is particularly widespread. The influence of solar outbursts on meteorological phenomena is usually indirect and not readily apparent. At the same time many cases of solar outbursts occur which are not very well observed and certainly not very clearly understood. Altogether there are some 70 solar stations operating around the year during IGY and the sun should be under observation during every instant of time throughout that period. In Ottawa solar measurements will be made throughout every day of IGY at a wavelength of ten centimeters. Information on the daily noise level from the whole solar disk and the times and intensities of noise from flares will be sent to the IGY warning service in Washington, D.C.

Scanning the Sun's Disc

Solar noise measurements will also be taken in connection with the radio ionosphere program on frequencies of 50 and 500 mc. At Ottawa there is a 10 ft. diameter radio telescope which automatically follows the sun and records intensity of total radio emissions. There is also a 150 ft. linear receiver which scans the sun's disc in narrow strips as the earth rotates and therefore is capable of locating spots of unusual activity. Solar radio noise is recorded by using an interferometer antenna at 50 mc which records only the radiation from the disturbed area. It will locate the radiation source on the sun with an accuracy of plus or minus 3½ min of arc. In addition, the record of solar noise is being taken continuously at 500 mc using a 20 ft parabolic antenna. Equipment is also being used at Alert to follow the sun during the summer. Radiation on 300 mc and 3,000 mc is being recorded.

The IGY cosmic ray program is planned to deal with three general questions in this field: (1) The mass and energy spectrum of the primary radiation; (2) The low



"Whistlers" are radio waves produced by flashes of lightning. They follow the earth's magnetic lines of force (arrows). A low-pitched "whistler" (right) results from a return trip after reflection from the opposite hemisphere

energy end of the primary spectrum, especially the possible cut-off to zero energy below 5 x 10 ev and (3) fluctuations and intensity. Canada has an important role to play in this work because of the large land mass in northern latitudes. The incoming cosmic rays are at their most intense level near the Poles because of the concentration there of the earth's magnetic lines of force. A series of flights using both rockets and balloons carrying cosmic ray recording equipment will be made at various latitudes. Flights are planned for both magnetically disturbed days and for quiet days.

Neutron measurements will also be made on various balloon flights and, like weather stations, the number of cosmic ray stations will probably run into several hundred. Measurements are being taken continuously at Resolute Bay, Fort Churchill, Ottawa and Sulphur Mountain near Banff. A rocket research into cosmic rays will be made from Fort Churchill. The observatory on Sulphur Mountain at an altitude of 7,500 ft will in fact serve both for cosmic ray studies and research in nuclear physics. It is a joint operation of the NRC and Atomic Energy of Canada Ltd. At the Sulphur Mountain Station, cubical triple coincidence counter telescopes will be operated together with neutron monitors and pulse ionization chambers. In the cosmic ray neutron monitor the counter tubes are embedded in slabs of lead and wax. Bombarding cosmic ray particles activate the counters which record the numbers and angle of approach.

From information gathered all over the world it is hoped that some of the mystery surrounding cosmic rays will be cleared up. These streams of electrically charged particles which are mostly positive parts of atomic nuclei appear to come from outer space impinging on the earth from all directions day and night. Their intensity appears to be related to the sun's activities for there is sometimes considerably more cosmic ray bombardment measured during periods of solar flares.

Magnetic fluctuations

Standard magnetic observatories all over the world have been making continuous routine observations of the earth's magnetic field for over 100 years. From these observations the magnetic field of the earth is known to be fairly stable but there are some variations, both slow and fast, which have been noted. The more rapid fluctuations arise from influences either in the upper atmosphere or above it. The main emphasis of IGY geomagnetic program consists of a series of experiments designed to yield facts about these rapid magnetic field fluctuations. The Canadian program will be operated at six stations: Meanook, Resolute, Baker Lake, Yellowknife, Victoria and Ottawa. Photographic magnetographs and electronic recording magnetometers will be used. At Meanook, earth currents are being recorded in two orthogonal directions over a path length of approximately 1.5 km. At the same time the rate of change of the corresponding components in the horizontal magnetic field is being recorded with a resolution of 0.01 gammas per second. The electronic magnetic variometers use the flux gate principle, recording variations in the components of magnetic field on a paper strip recorder which is set to indicate 1,000 gammas with full scale deflection. The equipment will record continuously the three components of the magnetic field.

Rocket firing program

Considerable work in Canada is also being done in the meteorological program and the meteorological service has 12 upper air stations normally operating within or nearly within the meridianal zone recommended for IGY. To a lesser extent work is also being done on glaciology, oceanography (in which major co-operation will be in conjunction with United States ships) and seismology, although this will be the normal program and no extension of it is being carried on. There is also an east-west chain of pendulum stations to help in getting a more detailed knowledge of the earth's gravitational field.

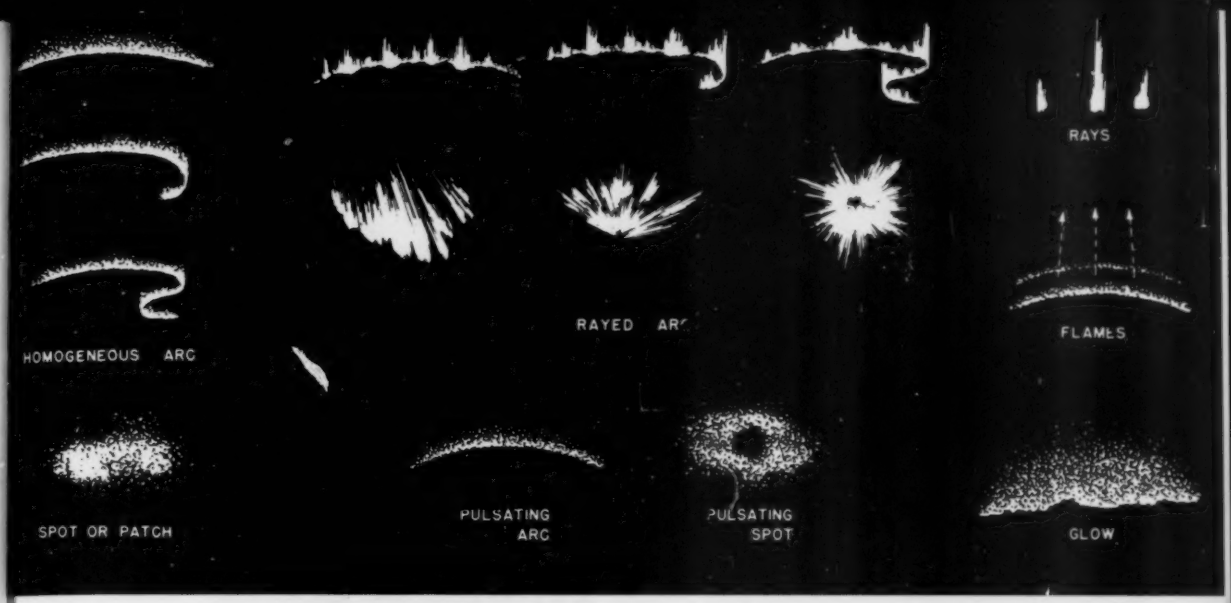
Many Canadian observers will be at Fort Churchill when United States groups carry out their rocket firing program. Of approximately 80 rockets to be fired about half will be Aerobees. This is a 30 ft rocket which can reach a height of 120 miles carrying 150 pounds of equipment. The rocket is propelled by reaction of fuming nitric acid with aniline alcohol mixture. It is assisted initially by a jet booster. The Americans will also be launching Nike-Deacons and Rockoons. The latter are light models which are launched from plastic balloons at altitudes of about 15 miles. Outside of Canada publicity is being centred on the launching of the so-called earth satellites. The United States plans to place six satellites in space but the launchings, due to the magnitude of the problems involved, will probably not take place until early next spring.

Final report in 1965

During IGY there are to be four types of specially designed world days, or series of days, in which special observing programs may be scheduled. There are "regular world days" to coincide with phases of the moon and prominent meteor showers; "alerts" when there is an unusually active solar region on the sun's disc; "special world intervals," which will be called on 24-hour notice when there is a possibility that a geomagnetic disturbance may set in; and "world meteorological intervals," 10-day periods in each quarter which will include the solstice or equinox day.

Compilation and analysis of all material gained during IGY will be a major job in itself. Canadian results will first be analyzed in Canada and then according to sections sent to the various world centres concerned. The results of the studies will be published in interim form even during IGY. Computers will be playing a big part in aiding the detailed analysis and they should help to get the final results out much earlier than for previous international events of this kind. For instance, the final report of the 1932-3 polar year was issued in 1951, although the work was interrupted in this case by the Second World War. The final IGY report running to many volumes should be published by 1965.

Dr. D. C. Rose, chairman of Canada's effort has said "the International Geophysical Year will see the pursuit of knowledge for its own sake. Pure science is not necessarily concerned with how knowledge is employed." However, it seems quite certain that IGY should add immeasurably to the store of scientific knowledge which in turn could produce big developments in every field. Certainly it is a fine example of how much scientific goodwill there is throughout the world. END



IAN R. DUTTON, ASSOCIATE EDITOR

New instruments record the aurorae

During the International Geophysical year Canadian Scientists will carry out an intensive research program to try and discover more about the aurorae. Two chains of observation stations will extend in a north-south direction to cut through the main belt of the Northern Lights. One begins at Alert (about 1,200 miles above the Arctic Circle), and extends down through Resolute Bay (700 miles to the south), Baker Lake (another 700 miles farther south), and Fort Churchill. A second chain farther west begins at Norman Wells and includes Yellowknife, Uranium City, Meanook (central Alberta) and Victoria. Observations will also be made at Saskatoon and Ottawa where auroral research has been in progress for some time.

In addition to this, a large number of volunteer observers (Meteorologists, airline pilots, amateur astronomers, etc.), have been recruited to record and report visual observations. These will augment the instrument records from the auroral stations.

Four main types of instrument will be used to record the Northern Lights. Some stations will be equipped with all four, while other stations will have only one or two. Beginning at nightfall and continuing through to daybreak, the All-sky Camera will make a photographic record of the entire sky to the horizon once every minute. This will provide a permanent record of the visual appearance of the aurora, as well as the position and time of occurrence.

The intensity, measured in terms of the International Brightness Coefficients, will be measured by Auroral Recorders using photomultiplier tubes. These scan a 15 deg. arc of sky from the north to the south horizon every five minutes. The instruments will provide punched tape records of the auroral intensities so that the information can be processed rapidly on computing equipment.

The gaseous content of the aurorae will be analyzed by a "Patrol Spectrograph" which records the spectral distribution of the light. This instrument continuously views a meridian of the sky from horizon to horizon, disperses the light in a 600 line-per-mm grating and records the spectral lines on film.

The fourth instrument is the Auroral Radar. Operating in the frequency range of 50 mc, it scans the four quadrants in sequence and measures the range of the aurorae. This is recorded on 35 mm film along with timing data which will be needed during analysis. The radar has one other feature — it can continue to operate on cloudy nights when visual instruments are "grounded."

Timing is very important in order that the final results can be properly analyzed with cross reference between the readings of different instruments at the same station and also between the observations at different stations throughout the world. Provision is made through an IBM timing system to synchronize the instruments which are actuated by an external electrical impulse. The other instruments contain their own programming systems with the timing checked at regular intervals and compensation made when necessary.

These instruments employ electronics in various ways. Full descriptions are contained in the reports on the following pages.

Camera mounted in upper housing photographs image of the sky in the curved mirror to record northern lights. Operation controlled by electrical impulse from master timer.

In this model, the camera and timer are mounted in the base. Camera aims through hole in curved mirror to second image in flat mirror above. Exposure is made every minute

New instruments record aurorae

Canadian all-sky cameras provide permanent record

The aurora, most physicists and astronomers believe, is caused by bombardment of the atmosphere by streams of charged particles emanating from the sun. As these charged particles are captured by the earth's magnetic field, they are channeled toward the geomagnetic poles, the areas where aurorae occur most frequently. They collide with and excite the atoms and molecules of the upper atmosphere, producing auroral displays in much the same manner an electric discharge causes a neon tube to glow.

The displays will be recorded and reported by a large number of volunteer observers using a standard form on which to sketch the results along with data on time, location intensity, etc. The displays will also be recorded on instruments that measure intensity, spectral content of the radiation, range and direction. But to provide a permanent visual record for future evaluation a camera has been developed that will photograph the entire sky down to the horizon.

The principle is quite simple—a curved mirror is set up with a camera directly over it. The reflection of the sky in the mirror is recorded by the camera.

Dr. J. H. Meek of the Defence Research Board, Geophysical Section developed one of the original cameras while carrying out northern lights investigations for DRB at the University of Saskatchewan. Several versions now exist and will be used at observation posts in Canada during IGY.

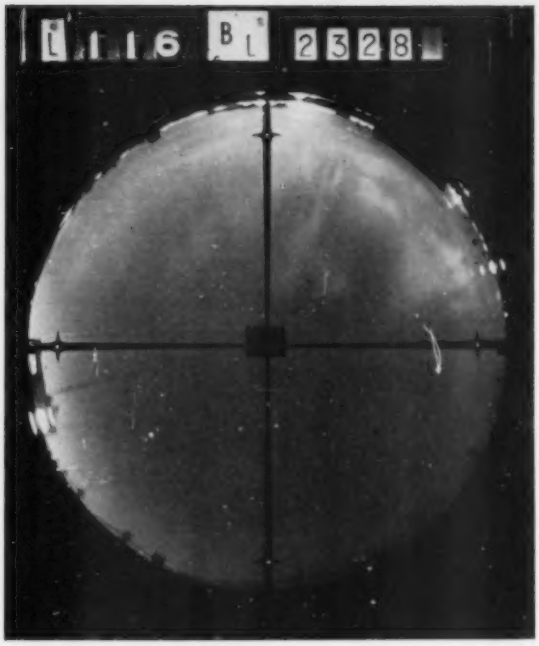
In one type of camera the actual recording camera is mounted directly above the centre of the curved mirror.

In another type, the camera is mounted beneath the mirror with its lens pointing upward through a hole in the centre of the curved mirror. The lens is aimed at a small flat mirror above it so that the image of the sky reflects from the curved mirror to the flat mirror, then to the camera.

The recording camera is electrically driven to expose the film at predetermined intervals. The controlling system is an IBM timer carefully synchronized in order that recordings from all over the world can later be compared. Electrical impulses actuate the shutter, advance the film and set the illuminated dials that indicate the time in each picture.

Some of the recording cameras will use 35 mm film while others will use 16 mm film. The choice appears to have been one involving the availability of instrumentation cameras to the two groups building all-sky cameras.

At the site, the camera is mounted on a stand, along with other auroral equipment, to keep it above the level of the snow during the winter months. From this, the camera will operate automatically each night to record the northern lights—provided the sky is not overcast.



This is what the All-Sky camera records—auroral displays along with time and location reference data from illuminated dials. Pictures from stations around the world will be evaluated to help us learn more about the northern lights

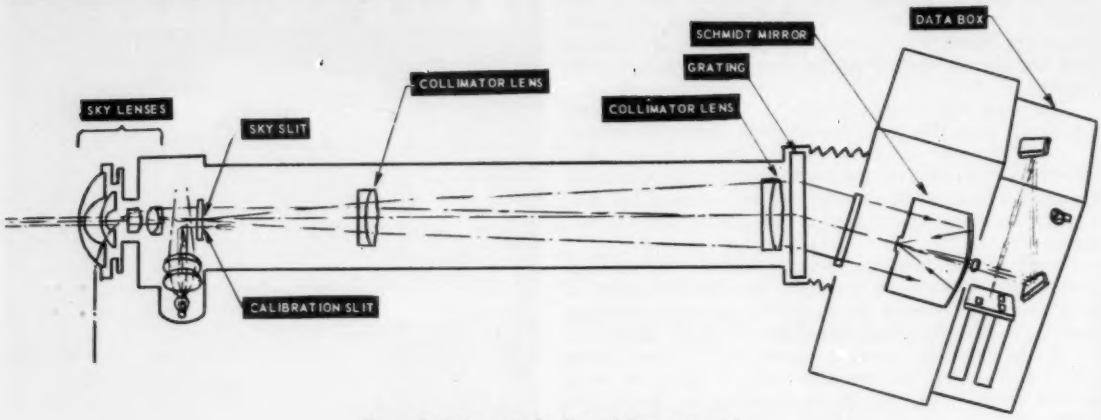
Patrol spectrograph determines chemical content of aurora

Most scientists believe that the Northern Lights are caused by ionization of the atmosphere as it is bombarded by streams of charged particles emanating from the sun.

In the IGY program for auroral observations, there will be studies of the various components of the aurora, including hydrogen, as functions of the type of aurora, its height and latitude. These data, particularly for the Arctic and Antarctic, when correlated with other geographical events, are expected to provide a basis for better understanding of theories of charged particles in the earth's magnetic field.

A different method of excitation, one resulting from chemical reactions in the upper atmosphere, is believed to be involved in the production of airglow. This phenomenon is the faint glow with which the sky is diffused day and night. It is not visible to the naked eye because it is so faint and because its strongest radiations are outside the visible portion of the spectrum. For the same reasons, it was not detected until several decades ago, and even

The Perkin-Elmer Patrol Spectrograph analyses auroral light to determine spectral content. Control is by electronics



Optical system of the Patrol Spectrograph

then, for some time was called the "permanent aurora" because spectograms of it showed a green radiation line always seen in the auroras. Now not only is it recognized as a distinct phenomenon, but airglow at night and airglow in daytime are believed to be produced by somewhat different mechanisms.

The main problem in airglow studies is its variation in intensity with time and place. The stronger components of the airglow spectrum are the OH bands in the infrared region; the red and green auroral lines, both emitted by oxygen atoms; and the D lines of sodium. Each of these undergoes different types of variations in intensity with time. In addition, all airglow radiations are irregular, exhibiting a "patchiness" over the sky. Data comprehensive both in time and area covered are necessary to determine what patterns, if any, exist and their causes.

The Patrol Spectograph is entirely automatic in operation and is designed to photograph spectra of aurorae occurring along a given magnetic meridian of the sky from horizon to horizon.

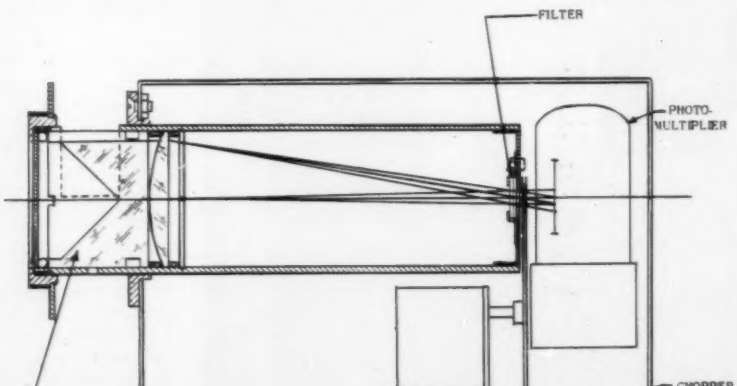
Radiation from the aurorae passes through a slotted metal dome at the top of the instrument and through a fish-eye sky lens which focuses the radiation on a narrow sky slit. The sky lens has the capacity to focus the light emanating from any point of the 180 deg. field (from horizon to horizon) on the slit. The light is collimated and then dispersed by a 600 line-per-mm grating into a spectrum.

The spectrum is brought to a focus by an optically high speed Schmidt camera and is recorded on 16 mm spectrographic film. It is possible to adjust the position of the camera to photograph a spectral region λ3500— λ6800, or λ4400— λ8800.

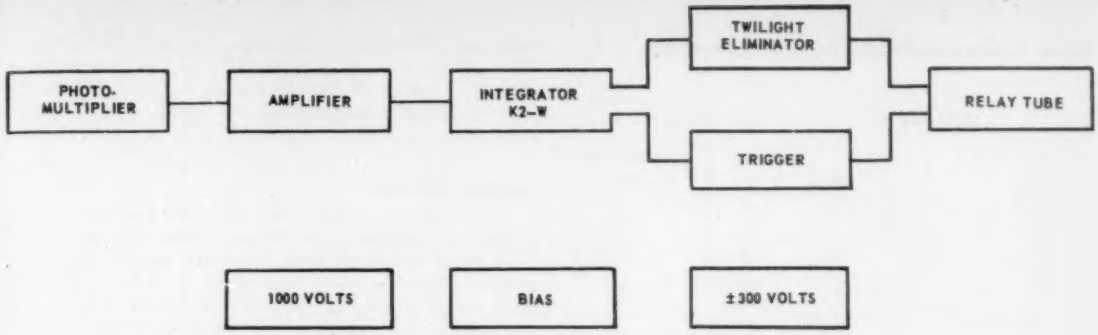
The length of exposure is determined by a photometer which integrates the amount of radiation falling on the sky lens. When the integrated light reaches a pre-determined level (as registered by a solenoid actuated counter) a data recording cycle is initiated. The purpose of this cycle is to correlate each spectrum photographed with (1) the time it was recorded (2) the film exposure number (3) the photon count accumulated during the sky exposure, and (4) related data such as the geographical location of the instrument. It also produces an exposure of a tungsten lamp through a calibrated neutral step wedge to provide an index to film characteristics.

The photometer optics

The optical system of the photometer consists of a plastic cylinder with an internal totally reflecting cone. Light entering the cylindrical surface in the plane normal to the axis is reflected by the conical surface and emerges parallel to the axis. This light is focused onto a circular



Line diagram of the photometer used to control the exposure time of the patrol spectrograph



Block diagram of the electronic circuit of the photometer

aperture, the diameter of which determines the effective angular width of the incident beam. This diameter is chosen to accept light from the same 2 deg. strip of the sky photographed through the sky slit. Five degrees at the north and south horizons are cut off from the photometer to eliminate the effect of ground lights.

The photon counter is so set that on a dark night, an exposure will be obtained every six to eight hours. During a strong aurora, naturally, much more energy falls on the photometer, the counts build up faster, and a great many more exposures are made. Similarly, if the night is so bright that the energy falling on the lens exceeds a predetermined level (as for example, a cloudy moonlit sky) the Twilight Eliminator goes into action, closing a shutter over the sky-slit and leaving the instrument ready to operate when the radiation level drops to the range of aurora and airglow intensity again.

A dielectric interference filter peaked at λ5577 is placed over the aperture so that this wavelength is the basis for the monitoring system. The radiation transmitted by the filter falls on a 1P21 photomultiplier after passing through a 1000 cps chopper wheel.

Photometer electronics

The function of the electronic system is (1) to provide an exposure such that the time integral of illumination at a given wave length is a constant, and (2) to close the sky shutter should the ambient illumination exceed a preset value.

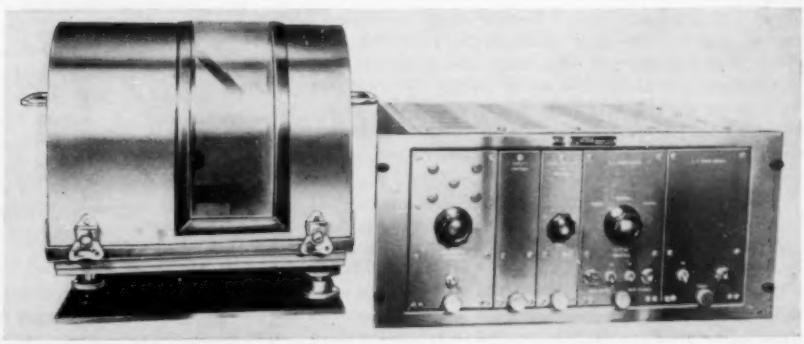
The signal from the photomultiplier is amplified by a feedback stabilized a-c amplifier, whose output is rectified and directed to the integrator and Twilight Eliminator.

The use of chopper radiation eliminates the effects of drifts in the dark current of the photomultiplier and provides the system with stability that is difficult to obtain by using unchopped radiation.

The Twilight Eliminator is a differential amplifier whose output drives half of the relay tube which, in turn, actuates a relay to close the sky shutter whenever the input exceeds a preset value.

The integrator is the same type used in analog computers with a balance circuit to minimize drift. When the output of the integrator reaches a critical voltage, a monastable multi-vibrator is triggered, driving a second relay which resets and balances the integrator.

Auroral recorder measures intensity of northern lights



Mirror in scanning head reflects auroral light to photomultiplier. Signal is recorded on punched tape

The work of several years on a program of photo electric recording of aurora led to the development of the Automatic Auroral Recorder by Dr. D. M. Hunten at the University of Saskatchewan. Final engineering and production were carried out at Canadian Applied Research Limited in Toronto. The instrument produces a photo-electric record of auroral phenomena, the tabulated results being obtained directly in the form of a punched tape to indicate the brightness of the auroral display and the position on a particular meridian in the sky. The punched tape also indicates the time of measurement of the phenomena and the presence of cloud or haze which might tend to obscure the aurora.

While the scanning is continuous, the recording is in

New instruments record aurorae

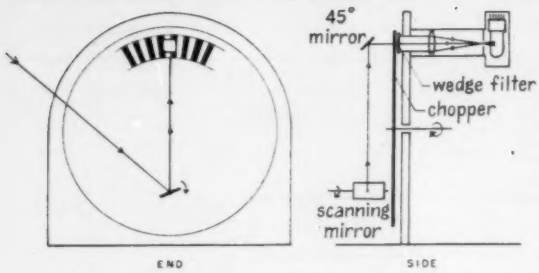


Fig. 1. Cross sections of the scanning head

steps with a code corresponding to the maximum intensity recorded during an interval. The code represents International Brightness Coefficients I to IV with each successive number indicating an intensity factor of 10. A record is also taken on a strip chart to provide an alternative visual record.

The Auroral Recorder consists of two major units, a scanning head and an amplifier assembly. The scanning head is provided with an optical system which permits continuous scanning a meridian of the sky from the northern to the southern horizons during a five-minute cycle. A sensitive photo-multiplier tube and selective interference type filter, having a response at 5577 A, is also mounted in the head assembly. A cathode follower output tube permits coupling to a low impedance cable.

To automatically turn the equipment on and off at sunset and sunrise, skylight entering the scanning head is deflected to a photo cell and relay circuit providing an electrical interlock.

The amplifier assembly, which may be mounted in a standard 19 in. relay rack, has been designed in modular form for ease in serving and maintenance. The modules are a power supply unit, amplifier, detector and discriminator. The circuits are arranged to actuate relays for each level of brightness which irradiates the photo multiplier —the intensity recorded being an integrated value over a 15-second interval.

The scanning head

Two cross sections of the scanning head are shown in fig. 1. The light is reflected from the scanning mirror, vertically upward and then horizontally by a small diagonal mirror. It passes through a light chopper, a wedge interference filter, a lens and an aperture before reaching the 1P21 photo multiplier. The lens and aperture limit the instantaneous field of view to 10° along the meridian and 15° across it. The scanning mirror turns at a steady rate covering the whole meridian from horizon to horizon in five minutes, then snaps back to the north and starts over again.

Since the information desired is the intensity of the auroral green line (5577 A), the instrument has been designed to automatically discriminate between auroral light and white light. The means of doing this in earlier instruments was to use three interference filters, one passing the desired wavelength and the others on each side. If the light path is alternated between (A) the centre filter and (B) a combination of the other two, adjustment can be made so that white light gives no alternating signal while the desired spectral line is efficiently chopped. In the Auroral Recorder the three filters have been replaced by a single wedge filter in which the wavelength transmitted varies along the width at a rate of about 40 A per mm. White light of some particular spectral distribution gives a constant photo current all across the slit as the chopper turns and therefore no alternating signal. Other distributions give an alternating component, but this can be shown to be 90° out of phase with the desired signal if the desire wavelength passes through the centre of the slit. The phase sensitive detector can therefore be adjusted to ignore it.

Amplifier assembly

The 2700 cps signal from the photo multiplier is amplified and rectified by a phase sensitive detector. About 17 v dc is subtracted from the result and the difference used to control a 2C53 tube which is in series with the high voltage supply for the photo multiplier. The gain of the dynode chain in the photo multiplier is very sensitive to voltage, varying nearly exponentially over a wide range so as to increase a factor of 10 for about every 110 volt increase in total voltage. The effect then is to change the photomultiplier voltage until the detected signal is a little more than 17 v; the output is the dynode voltage which varies nearly logarithmically with light intensity.

The dc output of the photo multiplier is proportional to the ratio of the white light intensity to the auroral intensity since the signal from the latter is kept constant. The dc signal is used to trip a warning circuit if it exceeds a certain level, since very bright white light might so overload the circuit as to give a false auroral signal.

The preamplifier is direct coupled in order to preserve the white light signal and uses 100% feedback to the free end of the photo multiplier load resistor. The voltage gain is therefore 1, but the feedback allows a much larger load resistor to be used and the effective gain is about 50.

A tuned circuit with a Q of about 20 improves the performance by reducing noise voltages. The next two stages are stabilized by plate-to-cathode feedback. An adjustable cathode resistor varies the feedback and allows the gain to be set to a desired value.

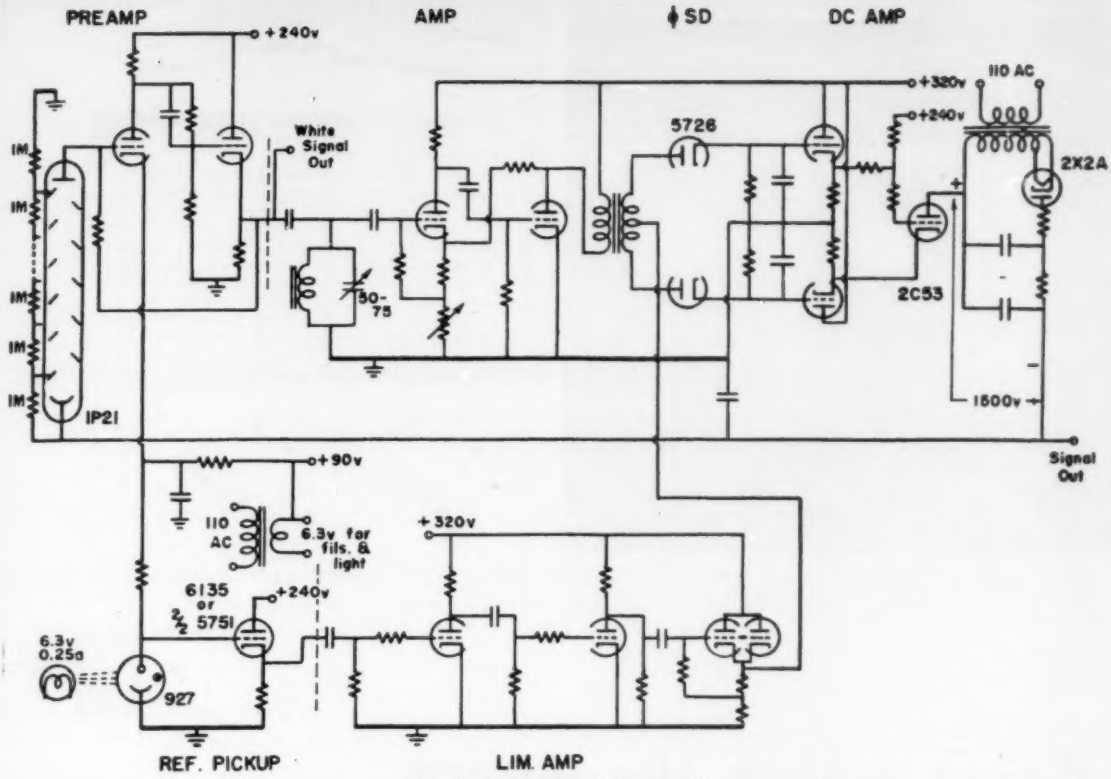
The phase sensitive detector is the type which forms the signal-plus-reference voltage and the signal-minus-reference voltage, rectifies both, and takes the difference. The two outputs pass through cathode followers which give a low impedance output to drive the 2C53. The 17 volt bucking voltage is injected into the grid circuit by a resistor network. The high voltage supply is floating so that the cathode of the 2C53 and the plate of the photo multiplier can be near ground. The load resistor for the 2C53 is the chain of 1-megohm resistors which distributes the dynode voltages.

The reference voltage is picked up from the chopper by a small gas-filled photo tube. The light source is a pilot bulb whose filament is heavy enough to fluctuate little in temperature during the ac cycle. A cathode follower is used as preamplifier and the signal then passes to a two-stage limiting amplifier whose purpose is to keep the reference voltage output constant. The second stage has a reduced plate voltage supply to make this output about 15 volts peak to peak. A second cathode follower gives a low impedance output to drive the phase sensitive detector. This phase adjustment is mechanical.

Output circuits

The output circuits comprise a series of discriminators producing the information to be punched on the tape and a vacuum tube voltmeter with a 0-1 milliampere Esterline-Angus recorder as the indicator.

The discriminators are preceded by a peak reading circuit which is re-set by a relay contact at the beginning of each 15-second interval. The intensity recorded is thus the maximum during the interval and trouble with the discriminators fluttering is eliminated. The voltage on the storage condenser is presented to the discriminators by a cathode follower. Each of these consists of a high mu triode with its cathode held at a fixed (but adjustable)



Auroral recorder amplifier assembly

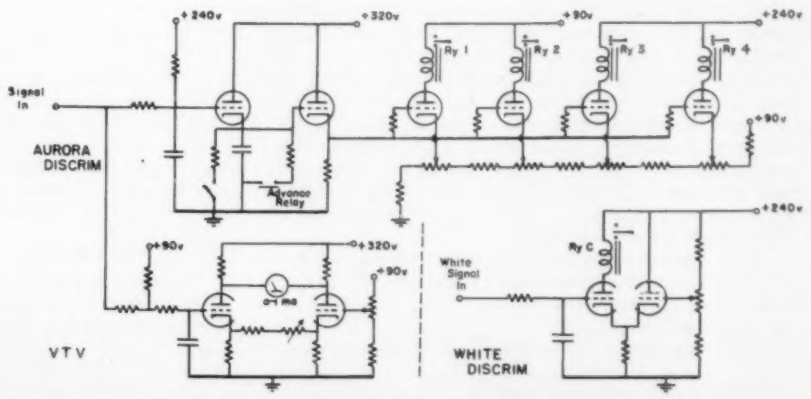
voltage and a sensitive relay in the plate circuit. Series grid resistors keep down the grid current when the input voltage is high and minimize the load on it. A low plate supply voltage keeps the plate current low under the same conditions. The bias voltages are adjusted with a standard source of the auroral green line so that each succeeding relay closes for a factor of 10 in intensity. This procedure allows for the considerable departure of the photo multiplier characteristic from a strict logarithmic curve. The closing of each successive relay indicates aurorae of International Brightness Coefficients I, II, III, and IV, and controls the punching of appropriate codes in the paper tape.

The white light discriminator is similar but uses a second triode for the cathode return. This requires less current and gives somewhat better stability. It is normally adjusted to operate when the ratio of white to auroral light is about 10.

Control circuits

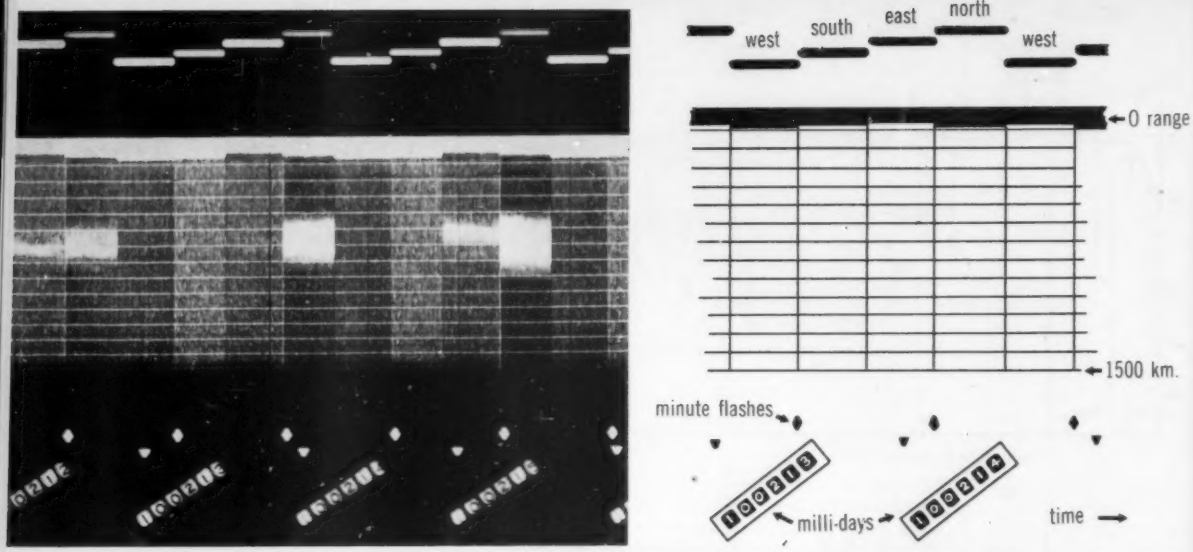
In the scanning head the mirror rotates through 90° to provide a complete scan from the northern to the southern horizons. The mirror shaft is driven by a synchronous motor operating through a speed reduction gear train and an electrically operated clutch assembly. As the mirror reaches the end of its travel a cam actuates a microswitch to de-energize the clutch assembly and allow a spring to quickly return the mirror to its starting position. The cycle is then repeated.

During the five-minute scanning cycle the tape recording circuit is actuated once each 15 seconds causing the digit which is set up by the discriminator to be punched.



Auroral recorder output circuits with discriminators actuating tape punching relays

all tubes are 5751 twin triodes except as otherwise specified



Film record of auroral radar echoes with time, range and quadrant marks. Calibrations are identified by the drawing

IGY

Radar probes the aurora

Dr. A. G. McNAMARA*

The IGY Auroral Radar has been designed to provide information on the location (range and quadrant) and intensity of aurora. This supplements the data from the other auroral instruments but has the advantage that operation will not be interrupted by cloud formations or daylight. Operation with photographic and chart recording is automatic on a 24-hour basis.

To avoid any discontinuity in recordings, operation must be reliable under the adverse conditions that may be encountered at any of the sites. This is more important at Resolute and Baker Lake where servicing can be difficult and replacement parts difficult to procure quickly. Conventional circuits were used where possible and moving mechanical parts minimized, particularly in the antenna array which is exposed to the weather.

Since auroral echoes are always obtained from low angles of elevation, the antenna system is designed to radiate strongly near the horizontal plane. A 'rotating beam' system, without physically moving antennas, is obtained by switching the receiver successively among the four corner-reflectors which are directed into the four quadrants, nominally designated as 'north,' 'west,' 'south,' and 'east.' Switching is controlled by a four-segment commutator driven by the gear train. The period of dwell in each direction is 30 seconds, the 'scan' being completed in two minutes. The gain of the corner reflector is 10 db above that of a half-wave dipole.

Simplification of the antennas and switching is achieved by radiating the transmitted power omnidirectionally with a vertical dipole, and putting all the directivity into the receiving antenna.

The transmitter is crystal controlled with two frequency multiplier stages bringing the output frequency to approximately 50 mc. The IPA and power amplifier tubes are type AX9903/5894 twin tetrodes in push-pull to give a nominal output of 1,000 watts peak with a duration of 300 usec at a recurrence rate of 70 pps. Screen modulation is used, with all frequency multiplier stages and power amplifiers being pulsed. This isolates the steady output of the crystal controlled oscillator from the final output.

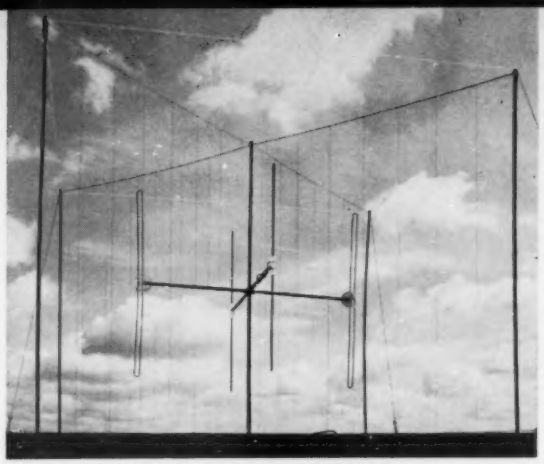
Incoming auroral echoes from the four receiving antennas are fed to the rf switch. Each, in turn, is passed through the crystal controlled receiver to the two recorders. The signal is displayed on a C.R.T. along with the range calibration marks. They are photographed to provide a record of range versus time. In addition to this the signal is fed through a signal integrator to a pen recorder to yield data on relative intensity of the echo or auroral display.

Since some of the IGY stations are located where power line frequency control is not sufficiently accurate, all timing functions, as well as the antenna switching, are derived from a precision tuning fork oscillator. This drives a 400 cps synchronous motor and gear train with moving contacts. Timing and dating indication on the records is by millidays, serial date and minutes. Hence a 6-figure electromagnetic counter can unambiguously identify the time and date for a period of nearly three years.

Camera records echoes

The CRT display is photographed by a camera using 100 ft. rolls of 35 mm film. The film advances continuously through the camera at the rate of one foot per hour. On the sample record and the explanatory drawing, time progresses toward the right. The transmitter ground pulse at zero range is the heavy white line and range is measured down-

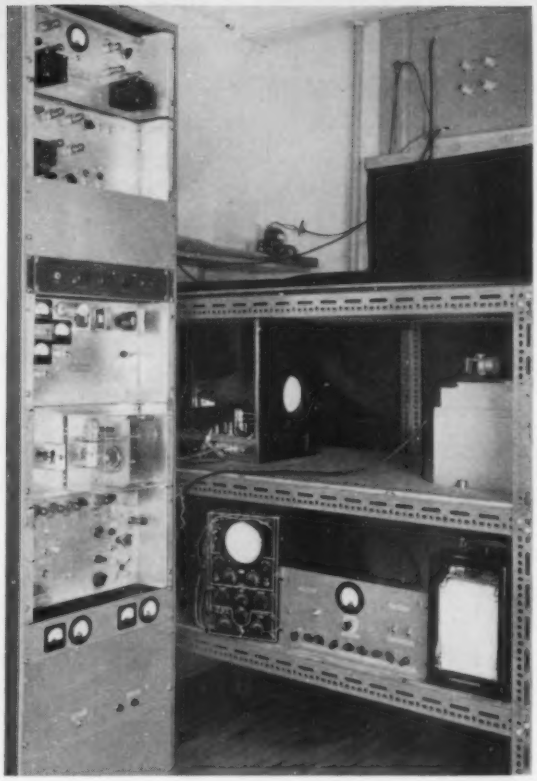
*National Research Council, Ottawa



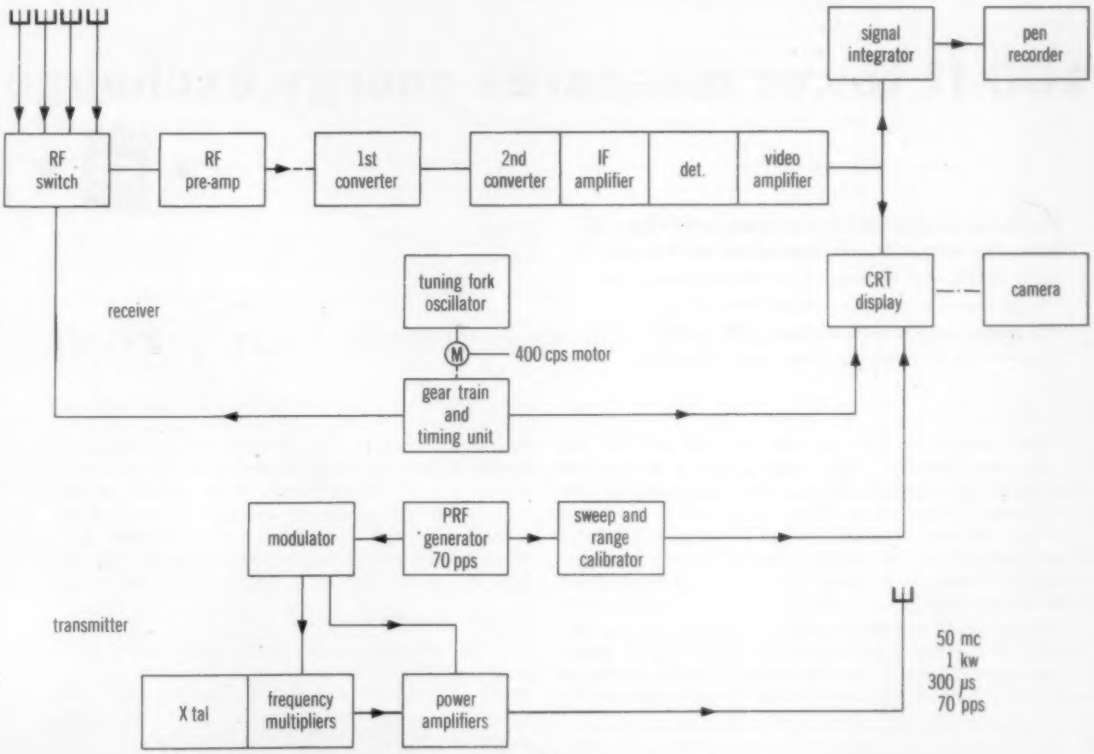
Four corner-reflector receiving antennas provide "beam rotation" by consecutively switching to each quadrant

ward. The white horizontal lines are 100 km range markers, the total displayed range being 1500 km. On the top edge of the film, the staircase presentation indicates the quadrant from which the echoes are being received at that period. Along the lower edge of the film, timing flashes and the illuminated decade counter are recorded. The triangles are milliday instants and the diamonds are minute instants.

All equipment, with the exception of the antennas, is located in a heated hut or building. The transmitter, receiver and power supplies are rack mounted in a 19-inch cabinet. On a nearby stand, the CRT and camera are placed in an enclosure that can be darkened sufficiently to allow good recording of the image without interference from the room lights. END



Transmitter, receiver and power supply chassis are rack mounted. On stand, camera records echoes shown on CRT



Block diagram of the auroral radar

Balloon and radiosonde. During IGY it is hoped to reach a height of 90,000 ft against the usual average of 70,000 ft

100-ft tower measures energy exchange

IGY

The meteorological research program at Resolute, in connection with IGY, has included the building of a tower which, with the help of electronic instruments, will measure the energy exchange through the atmosphere and its ozone content. This article describes the work that is being done at Resolute.

H. H. BINDON, M.A.*

From a specially built tower, rising 100 feet into the air, the meteorological office hope to get a tremendous amount of information during their program for the International Geophysical Year. The tower has been erected at Resolute and one of the primary purposes of the research there is to measure the total energy exchange through the layer of air separating the surface of the earth from the atmosphere.

Energy in the atmosphere may be exchanged by a combination of convective and forced heat exchange, by means of the vertical transfer of water vapor, and by means of radiations. Part of the solar energy passes down to the layer near the surface of the earth and is partially reflected by the surface and partially absorbed. In addition to this, the surface of the earth acts as an emitter of shortwave radiation which passes up through the atmosphere. The 100 ft steel mast at Resolute will determine this energy exchange, by measuring the meteorological parameters at 100, 40, 16, 6.4 and 2.6 ft. above the surface of the earth.

Camera keeps record

The temperatures are being measured by differential resistance thermometers to an accuracy of .2 deg. centigrade and are recorded on a Brown Recorder. The temperature sensing elements are protected from radiation by a suitable radiation shield and are aspirated. The wind velocity is measured by simple cup anemometers which are rotated by the wind at a rate proportionate to the number

*Head of the Instrument Division,
Meteorological Services, Toronto.

of miles passing the cups. The run of the wind is displayed on counters. These counters are photographed by means of an automatic Bolex camera at six intervals of five minutes. In addition a Bendix Friez Aerovane type of anemometer is located on top of the tower to record gusts.

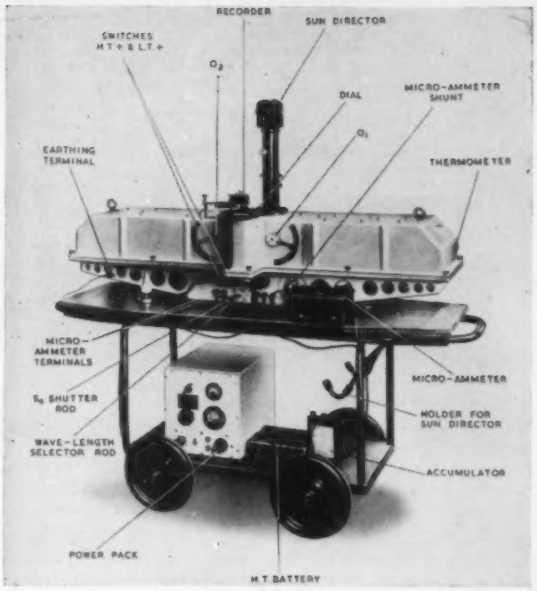
Humidity is to be measured by a dewpoint recorder which has been developed by the Meteorological Service. Samples of the air at various levels are drawn down through pipes and fed into an automatic dew point instrument. The dew point at various levels will be recorded on a thermocouple recorder. The energy exchange by radiation in all its facets will also be completely investigated. At the same time to meet normal IGY requirements special efforts will be made to get the radiosonde observations to very high levels. Special balloons are being used and it is hoped with these to reach an average height of 90,000 ft as against the usual average of 70,000 ft. The United States Weather Bureau type of radiosonde will be used and from these information on pressure, temperature, and relative humidity will be obtained. In addition information on wind direction and velocity will also be recorded by a direction finding system.

Instrument measures ozone

In addition to the investigation of energy exchange, considerable investigation is being carried out on atmospheric ozone. The ozone content of the atmosphere while small at the surface increases to a maximum of about 30 kilometers. The ozone will be measured by means of a Dobson spectrophotometer. This instrument measures the absorption of ultra-violet radiation from the sun in passing through the atmosphere. Photo-multipliers are used and very weak light intensities can be measured accurately. It is possible to use wavelengths which are strongly absorbed by ozone and therefore reduce the uncertainties due to varying haze and other minor troubles. The instrument has a wavelength which allows the wavelengths employed to be varied in a range of about 150 a.u.

A light coming into the instrument falls on a slit of the spectroscope. The spectroscope consists of a quartz lens which renders the light parallel, a 60 deg prism and mirror which reflects the light back through the prism and lens to form a spectrum in the focal plane of the instrument. The required wavelengths are isolated by means of slits in the focal plane and the ratio of intensities of radiation passing through two pairs of slits is measured.

A rotating shutter allows the two wavelengths produced to fall alternatively on a photo-multiplier. The variations



Dobson spectrophotometer will detect ozone in atmosphere

of current from the multiplier are amplified by a two-stage amplifier and the final current is rectified by a commutator carried on the same shaft as the rotating shutter. Thus, in general, as the current corresponding to the two wavelengths will not be equal, the galvanometer in the recified circuit will show a deflection, but if the two rays should produce exactly the same current in the photo multiplier there will be no current in the rectified circuit.

To use the instrument, one of the wavelengths is reduced in intensity to a known amount by the aid of adjustable optical wedges, and a measurement consists of adjusting the optical wedges until the galvanometer indicates no current when the position of the wedges is recorded. It is possible to use the instrument in very weak light and also when the sky is cloudy. By proper interpretation of the response, the actual ozone content at various heights may be estimated. Attempts are also to be made to determine the ozone distribution at night by making observations on the moon. This has already been done in Europe. END

Satellites start discussion on the laws of space

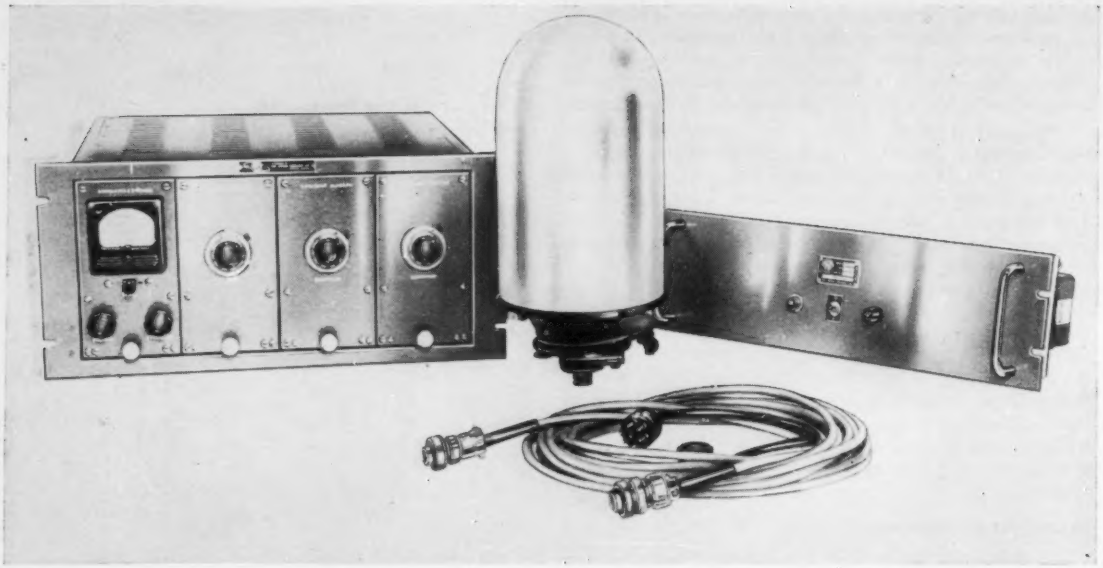
The launching of satellites into space during IGY has raised, once again, the question of who controls outer space. In general a nation's sovereignty is supposed to extend upward only to the limits of the atmosphere—taken as seven miles.

But Oscar Shacter, director of the United Nations General Legal Division, says that each nation's sovereignty should extend to the altitude where aircraft can be sustained in flight. On the other hand, Andrew G. Haley, chairman of the board of the American Rocket Society, says the limit should be where absolute pressure drops to zero, about 100 miles, while Dr. John C. Cooper, writing in the International Law Quarterly, suggests that nations own as far up as they can control.

The use of space, on the other hand, presents no more problems than the use of the seas. All nations are quite free to use space, although restrictions have been placed sometimes on aircraft flying. But the launching of the satellites has been agreed to by 50 nations and their flight over the various territories of the world is, therefore, legal under international law.

When science finally gets men and machines to the planets there will come the legal problem of who owns them and their mineral deposits. In the past bases have been established on newly discovered land. Columbus, to establish a firm claim on Haiti, left part of his crew as an occupation force; planting the Spanish flag would not have been enough. The Permanent Court of International Justice at The Hague has said that establishing a claim required the ". . . intention and will to act as sovereign and the exercise of such authority."

The probability seems to be that the planets, useful only for their mineral deposits, will be available to all nations who will stake out and work their claims.



T613 recording magnetometer comprises oscillator-doubler and component amplifiers (left), detector head (centre) and power supply (right) with interconnecting cables. Three recording voltmeters—one for each component—are also required

Magnetometer may reveal cause of earth field fluctuations

IGY

HAROLD PRICE, EDITOR

The magnetic field of the earth has been under continuous routine observation for over 100 years by standard magnetic observatories distributed over the earth. At the present time, there are almost 100 such observatories maintaind by the respective governments of the countries in which they are situated. From the data of these observatories the magnetic field of the earth is known to be fairly stable and unchanging. It is observed, however, to undergo variations, some slow, measured in years and some rapid, measured in days, hours, minutes and seconds.

These variations, although involving large amounts of energy when it is realized that they envelope the entire earth, rarely amount to more than 2% of the permanent magnetic field. They are seldom large enough to disturb a mariner's compass, but are easily recorded by the sensitive instruments of a magnetic observatory. It is known that the permanent field and the very slow variations are due to changes of some sort in the interior or in the crust of the earth and that the more rapid fluctuations arise from influences external to the surface of the earth.

These influences are not in the lower atmosphere, and therefore must be in the upper atmosphere or above. The main emphasis of the IGY geomagnetic program consists in a series of experiments designed to yield facts about the rapid magnetic field fluctuations. These will be recorded by the existing magnetic stations and by new stations set up in polar regions and in certain equatorial regions. The new stations, will, of course, obtain values of the permanent field as well as of the fluctuations. The fluctuations may appear only in high latitudes or may spread simultaneously over the entire earth. They are usually accompanied by disturbances in radio wave propagation, the ionosphere, and often by auroral displays; they increase with an increase in the number of sun spots, and grow less when the sun spots become less numerous.

It is believed that they are due to disturbances in the upper atmosphere of the earth caused by bursts of radiation of some sort from the sun, which may be charged particles of ultra-violet light and X-rays or both. The energy from the solar bursts may cause winds and electrical currents in the high atmosphere. Curiously enough, the main features of the magnetic disturbances are such as would be caused by three great electrical currents, measured in hundred of thousands of amperes, flowing in the upper atmosphere, two of which flow in the auroral zones of high latitudes north and south, and one in a zone around the equator. The equatorial current appears to have an extraordinary belt of greatly increased intensity concentrated in a narrow width of only about 200 km. The demonstration of the existence of these currents, their nature and their cause is an outstanding problem of geomagnetism and will be one of the objectives of the IGY geomagnetic program.

Canadian Geomagnetic Program

The Canadian geomagnetic program is the responsibility of the Dominion Observatory, Department of Mines and Technical Surveys, Ottawa. Photographic magnetographs will be operated at six stations: D, H and Z components will be recorded at Agincourt, Meanook and Victoria, and X, Y and Z at Resolute, Baker Lake and Yellowknife. Electronic recording magnetometers will record X, Y and Z at Meanook, Resolute, Baker Lake, Yellowknife and Victoria; D, H and Z will be recorded at Ottawa.

At Meanook, earth currents will be recorded in two orthogonal directions over a path length of approximately 1.5 km. In addition, the rate of change of the corresponding components of the horizontal magnetic field will be recorded with a resolution of 0.01 gammas per second (1 gamma equals 10^{-5} oersted). In connection with the Canadian auroral and inospheric programs, additional recording magnetometers will be operated at Churchill, Winnipeg, Saskatoon, Eskimo Point, Gillam and The Pas.

Five of the foregoing stations will be equiped with tape recorders of magnetic field fluctuations in the frequency band from 1 to 50 cycles per second. These will collect data to bear on the question whether the fluctuations in this band are due to electro-magnetic radiation fields from distant lightning discharges or from induction fields as from ionospheric currents overhead.

Results from the photographic magnetometers will be tabulated in the customary form of hourly average values, together with adequate summary readings of the magnetograms for special events such as sudden commencements, bay-type phenomena and so on. Magnetic observers will do as much of this work as possible at the observatories. Adequate photostating facilities will be arranged for the reproduction of any reasonable number of magnetograms requested by interested workers.

Type 613 Station Magnetometer

This station magnetometer, designed to record the three orthogonal components of the earth's magnetic field, was engineered and produced by PSC Applied Research Ltd. to assist in Canada's IGY measurements.

Designed by Dr. P. Serson of the Dominion Observatory, the magnetometer consists of three assemblies—a remote detecting head, an oscillator-amplifier, and a regulated power supply. In addition, three recording type meters are required. The normal sensitivity of recording is 1000 gammas full scale. Since the instrument gives a voltage output (1 volt dc per 100 gammas, at essentially zero output impedance), the recording sensitivity may be changed by changing the voltage sensitivity of the recording meter, and the magnetic field component may be recorded by more than one meter at different sensitivities.

The detecting head, which may be levelled, consists of the three orthogonal flux gate detecting coils enclosed in a polyester fiberglas cover. Particular care has beeen made in the design to ensure a firm mechanical assembly. Materials used in the head have been selected for freedom of magnetic properties, and have been finished to avoid deterioration due to corrosion.

The amplifier assembly, which may be mounted in a standard relay rack, has been designed in modular form; each of the component amplifiers may be plugged into the rack assembly. This method of construction permits rapid interchange of units for service and maintenance and, with spare modules, permits continuous use of the equipment.

The regulated power supply unit also mounts on a relay rack panel and is supplied with cables to the other assemblies.

The detecting head contains three magnetic detector units mounted with their axes of sensitivity mutually perpendicular. A detector unit consists of two parallel mumetal strips, each inside its own primary winding, surrounded by a common multi-turn secondary winding. The primary windings are oppositely wound, and the mumetal cores are carefully matched to produce a balanced assembly. The cores are carefully cemented at one end only, (opposite to terminal end) to ensure permanence of the balancing adjustments.

The oscillator-doubler unit contains a phase-shift oscillator operating at 660 cps and a push-pull output stage. It also include a rectifier type frequency doubler and output circuit to supply a reference voltage at twice the oscillator frequency.

Flux gate operation

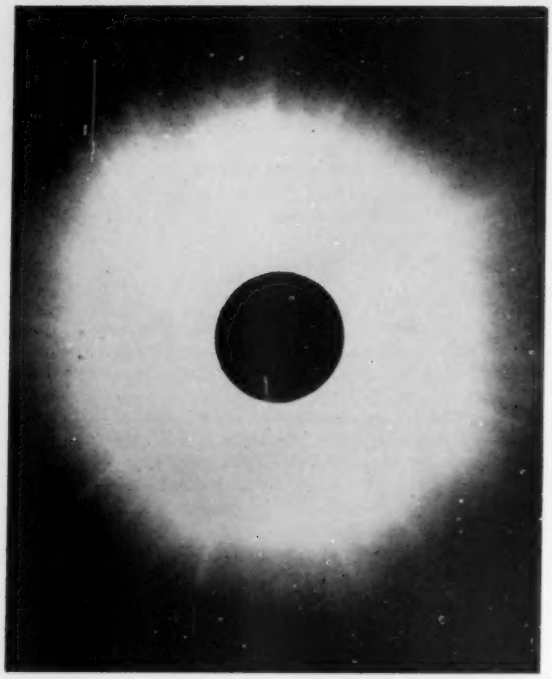
Each component amplifier contains a two-stage ac amplifier, a phase-sensitive detector and a dc amplifier connected as a feedback integrator, and a baseline setting circuit.

The 660 cps excitation current from the oscillator unit, passing through the primary windings of the three magnetic detector units in series, is large enough to saturate the mumetal cores for about 30% of the time. Since the exciting field is at least 10^5 times larger than the fields to be detected, the two cores become saturated and unsaturated simultaneously, to a very good approximation. During the part of the cycle when the cores are unsaturated, their high permeability increases the flux through the secondary winding due to an external magnetic field. When the cores become saturated, their permeability is small, and the flux through the secondary due to the external field decreases to the value it would have if the cores were not there. Thus a voltage is induced in the secondary winding with an amplitude and phase depending on the magnitude and sense of the external magnetic field. The component of this signal at twice the frequency of excitation current is strongly emphasized by tuning the magnetic detector unit with a 0.5 microfarad capacitor.

The signal from the magnetic detector unit is amplified and compared with the reference voltage from the frequency doubler in a phase-sensitive detector. The resultant dc voltage, which is proportional to the magnetic field at the mumetal cores (at about 0.5 volts per gamma), is integrated by the dc amplifier circuit. The output of the integrator is connected through a 370 K feedback resistor to the secondary winding of the magnetic detector, so that the current produces a magnetic field at the detector unit proportional to the output voltage of the integrator and in the opposite sense to the field producing the signal. The gain of the whole system is sufficiently high to hold the detector within the gamma of zero field. The output voltage of the integrator is thus accurately proportional to the magnetic field component along the axis of the detector, the constant of proportionality being fixed by the value of the feedback resistor and the geometry of the secondary winding. Since the output impedance of the circuit is essentially zero, several recording voltmeters can be operated by each component amplifier at different sensitivities if so desired.

In order to bring the recording meter on scale, the magnetic detector unit can be biassed by passing a steady direct current to the secondary winding. Turning the baseline control knob to the right increases this current. The range of adjustment for the X and Y base lines is 0 to +27,000 gammas, for the Z component +47,000 to +67,000 gammas.

The magnetometer head can be set in magnetic coordinates to record declination (D), horizontal intensity (H) and vertical intensity (Z), or it can be set in geographical coordinates to record north, east and vertical components. In the latter case, the declination determines whether the X or Y channel records the north components. END



The sun corona revealed at the time of total eclipse. Radio noise coming from the sun originates in the solar corona

Working outside the visible spectrum, the radio telescope is providing new information on the structure of the universe. This article gives a summary of the history of radio astronomy, the potentials of the new tool and a review of the work being done by the University of Toronto.

Star gazing with electronics

Story of how a new technique is being applied to an old science

The Crab Nebula, remains of a stellar explosion recorded by the Chinese in 1054 A.D. A very strong "radio star"

DONALD A. MacRAE PH.D* and J. L. YEN PH.D**

The discovery that the earth's atmosphere is transparent between 30,000 mc and 30 mc has given astronomers a new outlook and electronic engineers a challenging field for development of new techniques.

Astronomers, who for centuries had explored the universe through the narrow atmospheric window at optical frequencies, and communication engineers, whose field was the long-wave end of the electromagnetic spectrum seemed a world apart. But in the early thirties, when Karl Jansky began to explore the microwave frequencies, he found himself observing the Milky Way. Since 1945, radio astronomy has been one of the fastest-growing areas in both sciences.[1]

In free space, radio radiation and optical radiation differ only in frequency. But in the way they interact with material substances, in their modes of generation, and in the way they are absorbed, reflected, refracted and trans-

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mitted in a medium, the two act quite differently. This gives the astronomer an entirely different view and a new understanding of the physical processes going on in the universe.

The sun, a steady, reliable source of light and heat, is quite different at radio frequencies. In step with the sun-spot cycle, the sun is noisy and dyspeptic. Bursts of radio energy radiate from the corona, sparked by "flares" down on the surface, some of which are barely discernible optically. These disturbances, associated with sun-spots, also produce streams of corpuscles and increases in both the ultra-violet component of sunlight and cosmic rays. On the earth, minutes to days later, concomitant phenomena often take place, such as disturbances in the earth's magnetic field, northern lights, the break-down of radio communication, and increased flux of cosmic ray particles.

Because of this relationship, a radio watch on the sun is being kept during the International Geophysical Year, so that the various earth-science disciples can be alerted. A world-wide warning network has been set up. Later, the observations will be correlated to give us a better understanding of the behavior of the earth in the radiation field of the sun.

Study of the Milky Way

The sun is just one star among billions which make up the Milky Way galaxy. In the space between the stars is a medium, partly dust and partly neutral hydrogen with a density of about one atom per cubic centimetre. At 1420 mc (21 cm) this hydrogen emits radiation which, unlike light, is not obscured by the interstellar dust clouds. Thus the far reaches of the galaxy can now be explored, and by the Doppler frequency shifts, its rotation can be studied.

Here and there among and beyond the stars of the Milky Way, point sources of radio radiation, "radio stars," have been detected. One of these is the Crab nebula, recently shown to be a cosmic synchroton in which the radio noise is generated by high-speed electrons in a magnetic field. Perhaps 10 per cent of the cosmic rays received here on earth are from the Crab.

Another radio star has been shown to be two galaxies in collision, with their gas clouds clapping together at supersonic velocities. More electrical energy is generated there in a single second than mankind will use in millions of years. Although the galaxies are 200 million light years away their signal is as strong as that from the sun, barely eight light minutes away.

Astronomers have made exacting demands on the electrical engineers, and they feel the response they have received has been magnificent. Weak signals are, of course, the order of the day. Small differences in frequency must be resolved and measured. Electrical stability of equipment is of prime consideration. Large antennas are required not only to enhance the signal but also to provide increased angular resolving power. The performance of antennas and other equipment must be known on an absolute basis. These problems have stimulated research into extreme low-noise microwave amplifiers and the more efficient use of antenna systems. Although it is not yet possible to buy a radio telescope over the counter, it is gratifying that many components are already being manufactured to the required accuracy and tolerance.

The National Research Council in Ottawa was one of the pioneers in solar radio observations, and it is now in its eleventh year of continuous observation of solar flux at 10 cm. At the Defence Research Board solar observations at metre wave lengths are now being made and their study of the moon and scintillation of radio stars gives information on the ionosphere. Other projects are under way at Queen's University and at the University of Western Ontario. The Dominion Observatory, of the Department of Mines and Technical Surveys, will soon begin an extensive research program at a station in British Columbia. This work will be carried out in close association with the Dominion Astrophysical Observatory in Victoria, B.C., and also with scientific departments of the University of British Columbia. Initially the program will be concerned with the 21-cm radiation from interstellar hydrogen. It is proposed to erect an antenna 80 to 90 feet in diameter and construction may commence sometime in 1958.

Fig. 1. Radio telescope under construction at the David Dunlap Observatory, Richmond Hill, Ontario. Equatorially mounted array of zi-zag elements is being added soon

Measuring solar radio flux

At the University of Toronto a joint research program was undertaken a year ago by the Department of Electrical Engineering, under the supervision of Dr. George Sinclair, and the Department of Astronomy. One aim is to observe the sun at 300 mc during the daytime, to record the incidence of bursts and noise storms, and to provide an absolute measure of the solar radio flux daily at noon. Another is to make absolute measures of the flux from

High-gain receiver linked to pen recorder keeps a check on storms

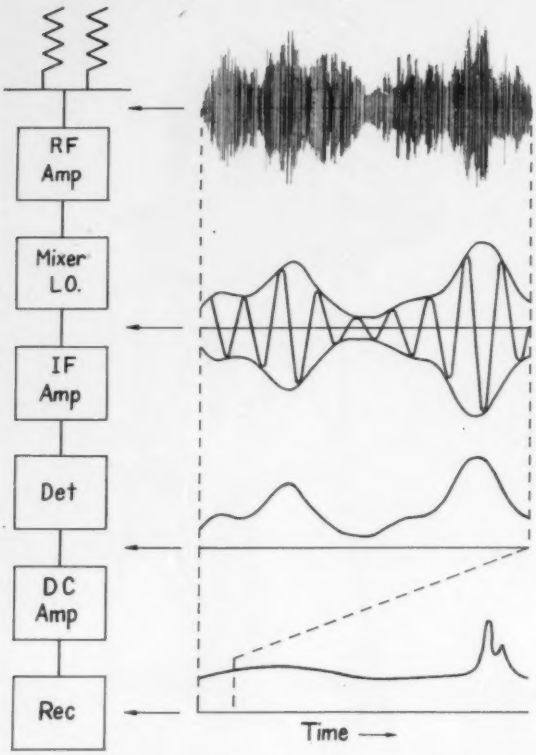

Fig. 2. Diagram of solar radiometer and wave-forms

radio stars at this and other frequencies in order to establish differences or similarities between the spectra of various types of cosmic sources. The equipment is set up at the David Dunlap Observatory in Richmond Hill. It will be described in some detail as an example of the essentials of a radio observatory.

The basic parts of a radio telescope are an antenna, a low-noise receiver, and a pen recorder. When used to measure the power radiated by the sun, or the solar flux density (watts per square meter per cycle per second), it is called a solar radiometer. Our equipment is designed for use at a frequency of 300 mc.

The antenna gain should be sufficiently high to produce a signal comparable to the receiver noise; since the sun is a very strong radio source, this is quite readily achieved. Further, the directivity should discriminate against the background noise due to the Milky Way. The physical size of an antenna is always limited by economic considerations and in order to obtain the narrowest beam width and highest gain it was decided to use a broadside array of end-fire elements. After a thorough investigation, the zig-zag form was chosen for these elements. The antenna consists of six of these, arranged in a 2 x 3 array, on an aluminum mesh ground plane 10 feet by 11 feet. They are connected together at a junction box and the signal is fed through a Tchebyscheff-type broad-band step transformer to the 50 ohm feed cable. The beam width of the antenna is ten degrees in both planes. When pointed due south, the antenna receives vertically polarized waves.

The antenna is equatorially mounted, that is, it can be rotated about one axis parallel to the earth's axis of rotation and another axis at right angles. This is the simplest way of arranging for the beam automatically to track the sun during the day, and it also provides that the direction of polarization remains fixed with respect to the sun. Quick motions provide slewing under manual control. The antenna and its mounting are placed on a 20-foot steel tower to reduce the effect of the radiation and reflections from the ground (fig. 1).

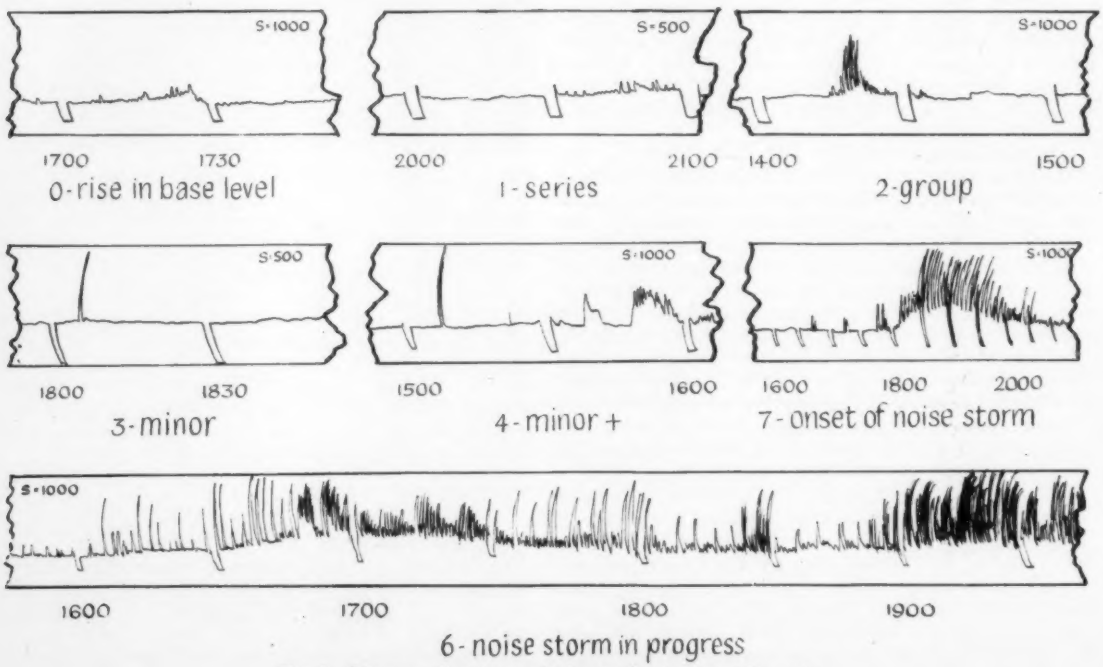

Fig. 3. Diagram showing typical records of solar radio noise

Fig. 4—300 mc horn antenna at the Dunlap Observatory

The main considerations in the design of the receiver are low noise, high gain-stability, and high sensitivity. A large bandwidth of 5 mc helps provide sufficient signal power. In other respects the receiver is conventional. Two grounded-grid rf amplifiers using low-noise tubes are employed to give a noise figure of about 4 db. A mixer stage converts the signal into 30 mc at which it is amplified by a 5 mc bandwith if amplifier of approximately 130 db gain. A linear detector converts the signal into dc which is then amplified by a chopper-stabilized dc amplifier. The output indicator is a galvanometer-type pen recorder. This and the dc amplifier serve as a post-detector low-pass filter with a time constant of half a second. Special gain-stabilizing circuits and highly regulated power supplies are used throughout so as to make it possible to detect changes in input power of one per cent of receiver noise. The wave forms of the signal at various stages of the receiver are shown in the block diagram (fig. 2).

Thus the radiometer produces a time-trace of the power received by the antenna in the frequency band 5 mc wide centred on 300 mc. Typical records are illustrated in fig. 3. At frequent intervals the input is switched to a standard 50 ohm resistor so that its thermal noise can be used to check changes in receiver gain. The over-all receiver response can be calibrated by means of a diode noise source and a precision attenuator.

The response of the receiver plus antenna can be determined only when the gain of the antenna can be calculated. For directional arrays and at vhf this is a rather difficult, if not impossible, task. However, for a pyramidal horn antenna, the gain can be calculated. Slayton[3] has shown that when Schelkunoff's optimum horn design is used the error is of the order of 0.3 db.

Our horn, shown in fig. 4, is constructed of welded aluminum, the inside being covered partly with expanded aluminum mesh and partly with aluminum sheet. Its aperture is nine feet by twelve feet, with slightly different slant heights of about twelve feet. It has a gain of approximately 60. Two steel pylons support a horizontal east-west axis so that the horn can be rotated in the plane of meridian. The feed is arranged so that vertically polarized waves are received.

When the horn is connected to the receiver a measurement of the absolute solar flux density can be made every day at noon. Furthermore, by a switching arrangement, the known output of the horn can be compared with that of the equatorially mounted array. This provides a measure of the gain of the array and permits the solar flux at other times to be determined.

Although the horn is primarily used as a standard of gain, arrangements can be made whereby it forms an interferometer with the equatorial array when it too is pointing in the meridian. The two antennas are separated by about 30 wavelengths in an east-west direction. When they are suitably connected to the receiver the output is of the form shown in fig. 5 over the period of time taken by a point source to traverse the beam as a consequence of the rotation of the earth. This arrangement has a resolving power of about two degrees and can therefore isolate relatively close radio stars and discriminate against the continuous background radiation. The absolute flux from the brighter radio stars can be measured in this way.

The equipment described was acquired with funds supplied by the National Research Council, while the radio laboratory was furnished by the University of Toronto. The apparatus was designed and assembled, and some of the components were built by a number of graduate students as part of their research projects. During the present summer seven students are associated with the project on an additional grant from the NRC, so that the undertaking is an important part of the educational work of the university, as well as a centre of research. Finally, it is one of the stations contributing to the world-wide research program of the International Geophysical Year. END

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2. *William T. Slayton, "Design and Calibration of Microwave Antenna gain standards." Naval Research Laboratory Report 4433, 1954.*
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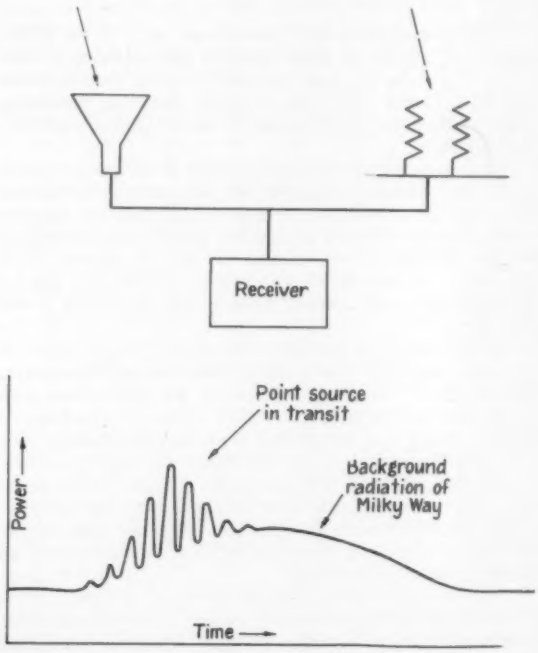
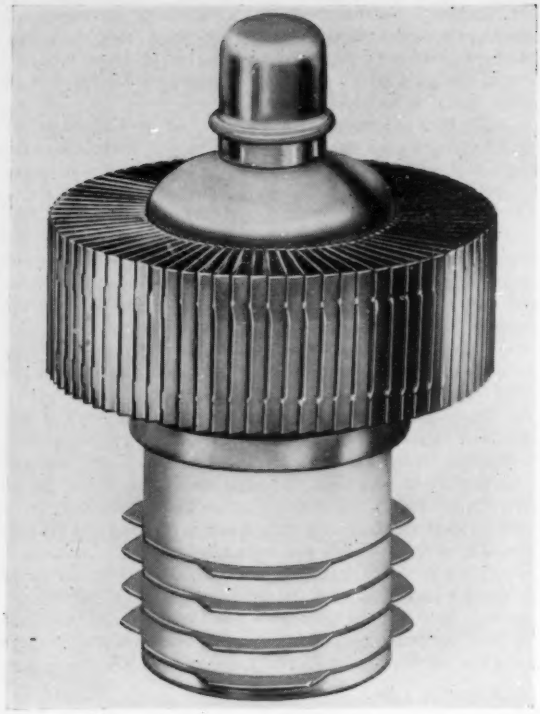


Fig. 5. Block diagram of interferometer and record of the transit of a radio star with background radiation



The design principles and features of a new one-kilowatt high-perveance tetrode are discussed here. High power handling capacity and operating temperature combined with low resultant distortion make this tube very useful in final linear amplifier applications.

Ceramics improve tetrode performance

JACKSON W. KENDALL, JR.*

The features of a new one-kilowatt tetrode, the X593, will be of interest to tube designers and application engineers. This tube has been designed to make the maximum use of ceramics as a tube structural material, producing improvements in the direction of better performance and dependability.

The improvement in dependability is very nearly automatic with ceramic structures, not only because of the fact that ceramic is inherently stronger than glass, but also because ceramic is more compatible with strong mechanical design. Therefore, this subject is not covered in detail. However, the importance of the high temperature characteristics of ceramic power tubes is discussed later in the article.

Mechanical improvement is not the only result of ceramic-and-metal construction. These new tube structures are capable of handling more power per unit volume than is usually encountered. In other words, a one-kilowatt tetrode today can be smaller than the one-kilowatt tube of yesterday. This is why the desire for high perveance arises in connection with these new designs. Perveance is the constant of proportionality in a vacuum tube that compares to conductance in a resistor. It is, to some extent, therefore, a measure of the ability of a tube to handle high power at moderate voltages.

Perveance is still not the whole story, however. If the power-handling capability of a tube is to be improved, every element within the structure must be considered: the cathode, control grid, screen grid, and plate. In the case of a ceramic tetrode, the power-dissipation capability of the screen grid is the most difficult to raise comparably with that of the rest of the tube. Therefore, an effort has been made in the design of the X593 to assure that at least some improvement will be made in the ability of the screen grid to perform its function in the presence of higher power.

Both perveance and screen dissipation have benefited by using the closest possible spacing. Close spacing not only increases perveance by virtue of the fact that less voltage is required to achieve a given current flow, but it also results in lower screen dissipation. Experience has shown that, in general, for a given plate current, screen current is not appreciably affected by screen voltage. Therefore, at the low screen voltages made possible by the closer spacing, screen dissipation is correspondingly reduced, provided only that the operating plate voltage, which affects power output, can remain unchanged. The X593 has been designed to operate to maximum capabilities at a screen voltage of less than 350 volts, and at a plate voltage of 2,500 volts. At this level, the tube is designed to handle an input of 1,800 watts with 25 watts screen dissipation. The low screen power compared to total input power is primarily the result of closer spacing.

Ribbon replaces wire

After this low operating power ratio has been obtained, it is still desirable to so construct the screen itself that it has good power-handling capability. To this end an improved screen-grid dissipation rating has been gained by the use of ribbon to replace the conventional round wire.

*Eitel-McCullough, Inc.

The ribbon, oriented to present its smallest side to the electron beam, has made possible increased heat dissipation from the screen grid both by radiation from an increased surface area, and by conduction through a larger cross-sectional area. This improved thermal performance was gained without an appreciable deterioration of the electrical characteristics.

One electrical improvement was obtained when the round wire was replaced by the ribbon. Grid-plate feed-through capacitance, which is normally high in a close-spaced tube, was reduced by a factor of 10 to 1. This reduction results in improved stability of the tube in amplifier circuits. This is particularly so in circuits which must be tuned over a wide range of frequencies.

High perveance can be obtained most easily with a uniform cathode. The indirectly heated, oxide-coated cathode was chosen because of its high thermal efficiency. Comparable results using a thoriated-tungsten filament would necessitate an excessive number of filament wires for the uniformity desired. The heating of such a thoriated-tungsten filament would require many times the 60 watts used in the X593. In addition, the excellent mechanical stability of the oxide-coated cathode structure made it a useful aid for aligning the grids, which could be jigged to it with a ceramic pin. The accuracy thus made possible has simplified obtaining the high perveance and linearity desired.

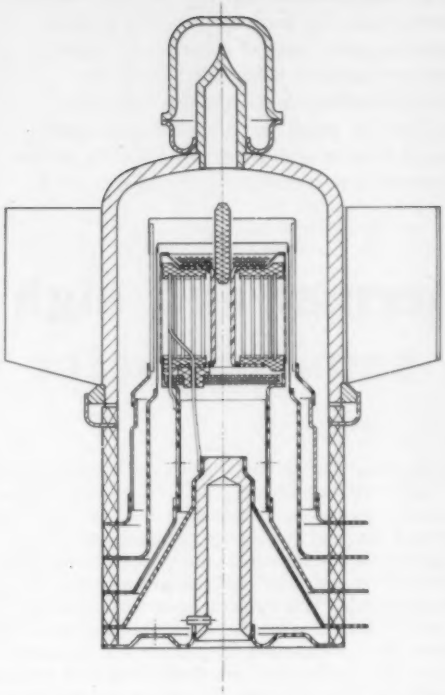
Amplifier distortion minimized

Linearity in an amplifier suffers when it becomes necessary to drive the control grid positive to obtain sufficient output power. This results in a condition of variable loading presented to the driver with resultant amplitude distortion. By the use of high-perveance tubes, such as the X593, this distortion is minimized primarily because it is no longer necessary to drive the grid positive to obtain maximum output power.

Linearity, however, is affected not only by electrical considerations. It is affected by mechanical alignment to the extent that a sharp cutoff characteristic inhibits what is commonly called "switching" distortion, or departure from the ideal at low signal levels. This general type of distortion, with different mechanisms involved, applies to both audio and radio-frequency linear amplifiers. No attempt was made to shape the cutoff characteristic to fit a predetermined curve. In this case, the effort was to obtain as sharp a cutoff as possible to avoid the degrading effects of remote cutoff, and one of the problems was holding the tolerances required in a close-spaced sharp cutoff tube.

Although the maintenance of control-grid tolerances is perhaps the most important dimensional consideration in an amplifier tube, all spacings are of some degree of importance. Using the stacked-ceramic techniques, all parts can be prepared to close tolerances and stacked into place with the aid of simple jigs. The completed assembly is brazed together with one pass through an 800 deg C hydrogen brazing furnace.

The 800 deg C brazing temperature indicates the ability of ceramic to withstand high temperatures. It should be recognized that the higher the operating temperature of a tube, the simpler the cooling requirement becomes. The limit of this operating temperature is set by the maximum temperature used during tube processing. The higher this processing temperature, the higher the permissible temperature of the tube in service. By processing the X593 at 600 deg C, many operational benefits have been gained. Higher temperatures force more of the occluded gas from tube elements. As a result, the tube, being cleaner inside, is capable of improved performance and greater resistance to overloads at higher operating temperatures.



Cross-section shows close grid spacing, rugged construction

High operating temperature

The operating temperature of the X593 is conservatively rated at 250 deg C. This is in the neighborhood of 100 deg C higher than a comparable glass tube can operate. This results in simplified cooling requirements, eliminating the need for a large or complex air-cooler assembly. Simple copper fins, brazed directly to the anode, form a more than adequate cooler.

Finally, in high frequency operation, the ceramic tube again has superior characteristics to its glass counterpart. This is due, in part, to the greater resistance of ceramic to electron bombardment. Transit-time effects at the higher frequencies can cause electrons to be deflected from the anode, striking, instead, the tube envelope. Resultant local heating of the envelope can be serious, placing a severe requirement on the thermal stability of the envelope material. The superiority of ceramics is due also to the fact that metal-to-ceramic seals will withstand higher operating temperatures, a desirable feature for high-frequency operation because of the heating effect which charging currents have on these seals at the higher operating frequencies.

Although ceramic parts cost more to prepare, the simpler assembly techniques and improved performance combine to offset this, with the result that the ceramic power tube is a high-quality tube at very little extra cost.

More and more, the electronics engineer is using the linear amplifier as the solution to his problems. The use of a single side band to get more information into less spectrum space is an example. One of the essential links in putting a single side band signal on the air is the linear final amplifier. It was for this service, and others requiring a linear amplifier, that the X593 was designed. However, there are many other applications for the X593. As a non-linear power amplifier driven by a small receiving tube oscillator, its use to replace the self-excited power oscillator has much to recommend it. END

Although semiconductor devices may be classified in various ways, for instance according to their frequency or power range of operation, Professor Burgess here considers them in the light of the physical mechanisms involved in their functions. Those cases in which the dependence of semiconductor properties on temperature and on electric field plays a significant role are examined in detail.

PROF. R. E. BURGESS*

Thermal and high field effects in semiconductor devices

During the last 20 years numerous applications have been found for semiconductors in electronic techniques. Previously, rectifiers and photocells were the only devices which had attained widespread application. Latterly the thermistor, the varistor, the transistor and the Peltier refrigerator have appeared; furthermore, the great advances in the preparation and fabrication of semiconductor materials have led to spectacular developments and improvements in the performance of rectifiers (from power frequencies up to millimeter wavelengths) and of photocells, especially for the infra-red and for solar radiation conversion.

Although semiconductor devices may be classified in various ways, for instance, according to their frequency or power range of operation, it is here proposed to consider them in the light of the fundamental physical mechanisms involved in their functions. In particular those cases in which the dependence of semiconductor properties on temperature and on electric field plays a significant role are examined in detail. In some devices these two factors are intentionally exploited in device design to yield the desired characteristics e.g. the thermistor and the silicon avalanche diode (formerly misnamed the Zener diode). On the other hand, these phenomena may operate in a detrimental fashion as for instance in limiting the usefulness of a junction transistor where internal heating by the applied power produces deterioration of the characteristics, and where increased collector voltage ultimately causes punchthrough of the base region or breakdown of the collector junction.

Study of these effects provides a means of investigating the fundamental physical processes which occur in semiconductors and thence ultimately leads to the improvement of existing devices and to the development of new devices. The avalanche diode and transistor gives examples of a process (the multiplication of charge carriers by collision ionization) which was initially mistaken for a different process (internal field emission from the valence to the conduction band), then investigated in careful detail both experimentally and theoretically and, when fully understood, was exploited to provide novel circuit elements which are designable and reproducible. It can be confidently asserted that present research on the basic phenomena involving electrons, holes and ions in semiconductors will continue to suggest many new solid-state devices which will in some cases surpass the vacuum tube in terms of efficiency, frequency range, noise and operating life and in other cases perform functions not previously possible.

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Thermal effects

It is a well known property of many semiconducting materials that the resistivity decreases appreciably with increasing temperature. Whereas a metal at room temperature may have a positive temperature coefficient of resistivity of about 0.4% per degree C, some semiconductors have a negative coefficient of about 4% per degree C which is ten times greater in magnitude. The basis of this property lies in the thermal excitation of free charge carriers (electrons and holes); at any given temperature the equilibrium concentrations of electrons and holes represent a balance between thermal generation and recombination and in general the greater the ionization energy required to generate a carrier the more rapid is the increase of these concentrations with temperature.

These considerations led to the development of the thermistor[2] which consists of a piece of semiconductor material (composed of a mixture of several oxides) to provide a stable two-terminal circuit element whose current-voltage characteristics are essentially linear if its temperature is held strictly constant, but display a voltage maximum if its temperature is allowed to rise freely as the applied electric power is increased. Thus the intersection of the linear isothermal characteristics with the hyperbolae of constant power gives the static characteristic corresponding to a fixed ambient temperature. The static characteristic of a typical low resistance thermistor is shown in fig. 1. At a current of 20 ma the voltage reaches its

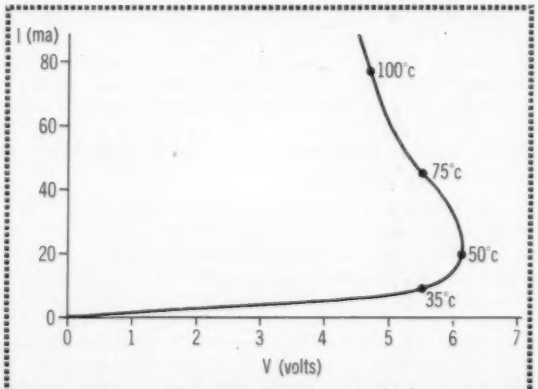
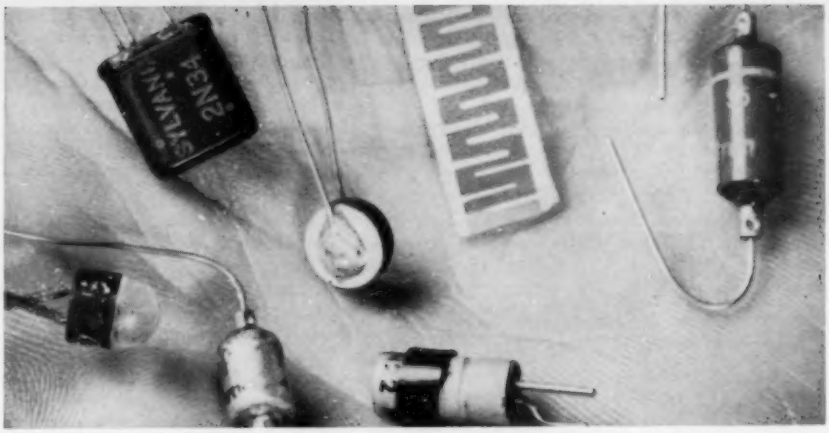


Fig. 1. Static characteristic of typical thermistor at 25C ambient temperature. Temperatures attained by the thermistor at various applied powers are shown



Shown here is a selection of components, including some of the semiconductor devices whose operation is covered in the article
Top row, l. to r.: junction transistor, photo resistor, silicon junction diode
Centre: thermistor
Bottom row: photo resistor (sensitive only to pinpointed light), capacitor, switching type transistor

maximum or turnover value of 6.1 volts and at larger currents the differential resistance is negative.

Quantitatively the resistance of a thermistor at absolute temperature T has the form $R = A \exp (b/T)$ to a close approximation; A and b are constants and the temperature coefficient of the resistance is b/T^2. Thus for $T = 300$ K (27 C) and $b = 3600$ (a typical value) the temperature coefficient is 4% per degree. When a power $P = IV$ is dissipated in the thermistor its temperature rise above the ambient temperature T_a will be closely proportional to the power and thus the static characteristic takes the form $V = AI \exp [b/(T_a + cIV)]$ which is non-linear and has the following essential features:

(i) for small applied power, ohmic behavior
$$V = AI \exp (b/T_a)$$
(ii) a voltage maximum (or "turnover") occurs if
$$b > 4T_a$$
(iii) a negative differential resistance (dV/dI) for currents above the turnover value. (At at much higher current a voltage minimum would occur at a temperature approximately equal to b, but in fact the thermistor would have burnt out long before such a power loading is attained.)

For the thermistor of fig. 1, the parameter b has the typical value of 3,600 deg and c is 0.2 deg per milliwatt, while the resistance for negligible applied power is 1,000 ohms.

A consequence of the turnover phenomenon is that the operating point of the thermistor may be unstable or even "run away," depending upon the emf and resistance of the source of dc voltage used to supply it. When a thermistor is biased through a series resistance S and fixed supply voltage V_s (greater than the turnover voltage V_t), the load line may intersect the static characteristic at one, two or three points or not at all. When the load line intersects at three points, only the outside two are stable since at the middle point a slight perturbation of temperature or power would cause the operating point to move away and settle at one of the others. If the load line does not intersect the static characteristic but lies always to the right of it, the thermistor will heat up until it burns out—the condition of "runaway." In order to understand these examples of instability the dynamic equation for the excess temperature Θ ($= T\text{-}T_a$) must be used:

$$\frac{d\Theta}{dt} = \frac{cP - \Theta}{\tau}$$

where τ is the thermal time constant of the thermistor. This shows that the temperature of the thermistor will increase when the instantaneous operating point lies to the right of the static curve and will decrease if it lies to the left.

Many interesting applications[2] of the thermistor rely on the existence of thermal inertia and on the form of the static characteristic. Examples are: voltage stabilization, limiters, compressors, delay devices and temperature compensators; at sufficiently low frequencies (of the order of or smaller than $1/\tau$) they may be used as oscillators, amplifiers and modulators.

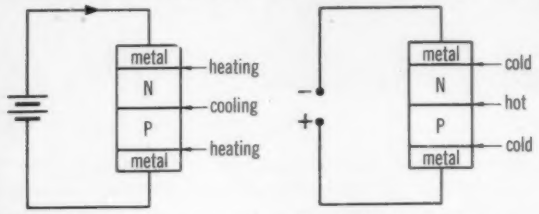
Some of the thermal features of thermistor behavior are found in other devices such as the point-contact germanium diode and the junction transistor. The point-contact diode has a reverse characteristic qualitatively quite similar to that of a thermistor and displays turnover which limits the peak inverse voltage[3]; however, diode turnover, while partly thermal in origin is complicated by the high field effects which occur concomitantly and will be discussed in the next section. The permissible power loading of the collector junction of a transistor is limited by the maximum acceptable temperature rise and by the requirement of absolute freedom from risk of runaway.

Thus extremely good thermal connection between the collector and a heat sink is the aim in power transistors and this corresponds to reducing as far as possible the coefficient c, the temperature rise per unit power in the steady state. This quantity is frequently quoted in manufacturer's data in terms of the "derating" since the reciprocal gives the reduction of permissible power loading which must be imposed per degree increase of ambient temperature for a given steady state collector temperature. In germanium power transistors the over-all coefficient c will be about 3 to 5 deg C per watt; the collector saturation current I_{co} has a positive temperature coefficient of about 10% per degree. The condition for stability is that $cV_c (dI_{co}/dT) < 1$ which corresponds to $V_c I_{co} < 10/c$ watts. Hence both I_{co} and c must be sufficiently small to avoid thermal runaway.

The advent of silicon of adequate purity, crystallinity and carrier lifetime has somewhat relieved the stringency of temperature restrictions hitherto imposed on junction diodes and transistors when manufactured from germanium. The larger intrinsic ionization energy of silicon enables extrinsic conductivity to be substantially maintained up to appreciably higher temperatures. For instance with 1 ohm cm base resistivity in a PNP transistor at room temperature the reverse saturation current density at 100 C is about 0.1 amp/cm² in germanium but only about 10^{-8} amp/cm² in silicon.

Completely different applications of the termal properties of semiconductors arise from two thermoelectric phenomena[5]: if a current flows through a closed circuit comprising two dissimilar materials (e.g. two metals, a metal and a semiconductor or n- and p-type semiconductors) heat will be liberated at one junction and taken in at the other junction depending on the direction of the current (the Peltier effect) as illustrated in fig. 2a. Conversely, if the two junctions are at different temperatures a thermoelectric emf will cause a current to flow around the circuit (the Seebeck effect) as illustrated in fig. 2b. These effects

Fig. 2.
Peltier and Seebeck effects in semiconductor junctions



(a) Peltier effect - - - - - Absorption and release of heat when current flows

(b) Seebeck effect - - - - - Appearance of emf with differences of temperature

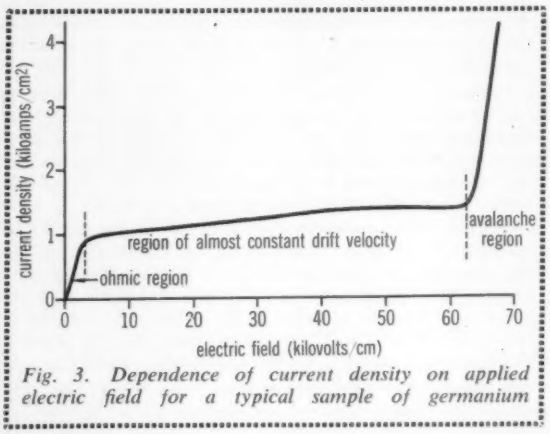


Fig. 3. Dependence of current density on applied electric field for a typical sample of germanium

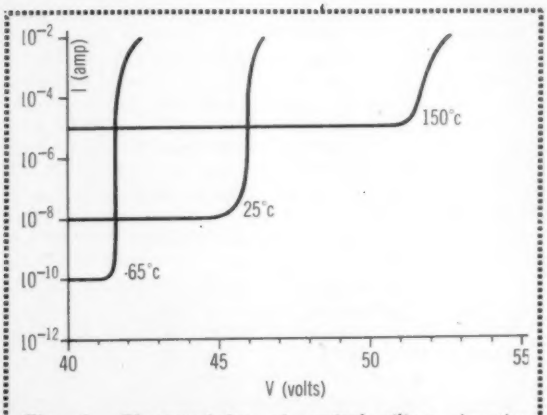


Fig. 4. Characteristics of typical silicon junction diode in the avalanche breakdown region. Note logarithmic scale of current, indicating a very abrupt increase of current as voltage exceeds breakdown value

are thermodynamically related and are large for semiconductors. The Peltier effect has obvious application to a solid-state refrigerator in which there are no moving parts and the "working fluid" simply consists of the charge carriers which are caused to flow across the junctions by the applied current. Such a device has already been constructed on an experimental basis[5] using a thermocouple of n- and p-type bismuth telluride which gave a cooling of 40 C below the ambient temperature.

Similarly the Seebeck effect holds promise for the efficient conversion of thermal to electrical power by the use of semiconductor thermocouples. In both the Peltier and Seebeck effects an essential requirement is that for a given thermoelectric power the ratio of the electrical to the thermal conductivity of the semiconductor shall be as large as possible to minimize the effect of internal heat transfer from one junction to the other. The problem of "designing" semiconductors with as large a Peltier coefficient as possible and yet with a low thermal conductivity is a challenging problem which is receiving attention in a number of research laboratories[6].

Effects of high electric fields

Whereas at low electric fields, say below 1,000 volt per cm., semiconductors give proportionality of current to applied voltage, this ohmic behavior is departed from in strong fields. Two main effects occur, first a reduction of carrier mobility, i.e. the electrons and holes drift with a velocity which is not proportional to the applied electric field but which increases less rapidly than the field and eventually almost reaches a constant saturation velocity which is typically of the order of 6×10^6 cm per sec. in germanium and silicon at room temperature.[10,12] As the field is further increased the second effect, avalanche breakdown, occurs and this causes a very rapid increase of current with increasing field; this is similar to the mechanism of the Townsend discharge in gases and is due to the electrons and holes acquiring sufficient energy from the field during their free paths to be able to ionize atoms of the crystal during lattice collisions thus releasing further holes and electrons which drift off in opposite directions and repeat the process. In this way a "positive feedback" mechanism is set up in which a single carrier entering a high-field region can cause the flow of an enormous number of carriers[7,8]. Now it is clear that the large fields of about 100,000 volt/cm needed for this effect to occur can only be sustained over a narrow region (10^{-4} to 10^{-3} cm. thick) within the semiconductor, and this region corresponds to the space-charge depletion layer of a reversed bias junction in a diode or at the collector of a transistor. The dependence of the current density on electric field is exemplified approximately in fig. 3 for the case of 2 ohm cm n-type germanium and the three regions of conduction mechanism are illustrated. The difficulties of experimental observation of these effects is indicated by the enormous specific power dissipation involved even before the avalanche region is reached e.g. 80 megawatts per cm^3 at 60 kilovolt per cm. This calls for very refined pulse technique and cooling arrangements.

The effect can be either desirable or undesirable according to the operation of the device. In the silicon voltage-reference diode there is deliberate exploitation of the breakdown process to give a very rapid increase of current with voltage above the breakdown voltage e.g. a 1000 : 1 current ratio for less than a 1% voltage increase of voltage (fig. 4). It should here be remarked that despite the somewhat catastrophic innuendo of the word breakdown the process is in fact reversible and reproducible and, providing that excessive heating is avoided, no damage to the device is entailed.

To a milder degree, the process of avalanche multipli-

cation can be used in the junction transistor by careful choice of collector voltage to give an alpha somewhat greater than unity and thus permit some of the circuit applications hitherto associated with the point-contact transistor[9]. However, further increase of collector voltage leads to avalanche breakdown in which condition the transistor becomes unusable.

A feature of theoretical and practical significance is that the breakdown voltage of a given junction has a positive temperature coefficient of about 0.1% per deg. in silicon, as is illustrated in fig. 4. There is evidence that for junctions of low resistivity material giving a low breakdown voltage of the order of 5 volts the temperature coefficient is very much smaller. It will be realized that the positive temperature coefficient helps to avoid thermal runaway in avalanche devices. A further important aspect is the essentially statistical nature of the avalanche discharge and this implies that it is inherently "noisy" and also that the current-voltage characteristics become dependent upon the nature of the voltage source.

In high-frequency junction transistors (and in junction diodes using a thin wafer of high-resistivity semiconductor) the depletion layer[4] which extends across the base from the collector as the reverse bias is increased will eventually reach the emitter. In this condition of "punchthrough," normal transistor action is no longer possible since the emitter potential must follow variations in collector potential very closely[11]. However the diode formed by emitter and collector (base floating) has characteristics[13] which may find application in specialized circuits. The form of the current-voltage characteristic of a PNP germanium diode is shown in fig. 5 for the case of a punchthrough voltage of 20 volts and a breakdown voltage of 30 volts. These values correspond approximately to base material of 0.2 ohm cm resistivity and a base thickness of 2 x 10-4cm.

In summary, there are three limits imposed on the voltage excursion of the collector voltage in a junction transistor: heating, breakdown and punchthrough, and the particular process in a given transistor which operates as a practical restriction is determined by the base thickness, the base resistivity and the collector cooling facilities.

Varistors

Another type of device which depends on non-linear conduction under high field conditions is the silicon carbide varistor[1], such as those made under the trade names of Thyrite or Metrosil. These consist of a mass of silicon carbide granular crystals pressed between two metal plates to provide the contacts, sometimes with a bonding provided by firing the material in a ceramic. Such devices exhibit symmetrical non-linear current-voltage characteristics in which, for voltages above a certain threshold voltage the current increases rapidly as V^n where n is about 4 or 5. The main application is for surge suppression, overvoltage protection and impulse limitation. The mechanism is probably one of conduction over the double barriers between the granules of the semiconductor; both thermal and field emission of electrons will occur at these barriers but as the voltage is increased the field emission is expected to rise rapidly due to an enhancement both of the emission current density and of the area of the barrier over which it flows [14].

Other types of varistor[15] have asymmetrical non-linear characteristics and depend upon rectifying contacts to copper oxide, selenium copper sulphide, silicon or germanium. The power limitations of these devices are set by a combination of field and thermal effects and in many of them an overload produces an irreversible and detrimental change of characteristics. END

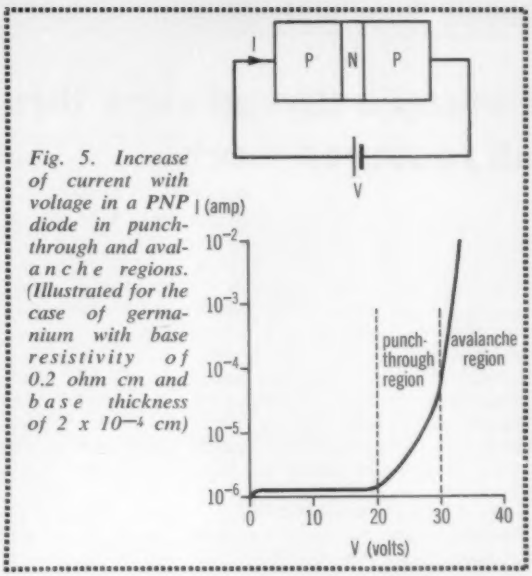


Fig. 5. Increase of current with voltage in a PNP diode in punch-through and avalanche regions. (Illustrated for the case of germanium with base resistivity of 0.2 ohm cm and base thickness of 2 x 10⁻⁴ cm)

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Common thread runs through all research work

That science and engineering are constantly finding new fields to explore and thereby constantly branching out in many new areas like the roots of a tree is today an obvious fact. This has a tendency to isolate technical groups from one another and make the task of keeping posted on technical developments more difficult for all scientists and engineers. But it is an extremely necessary effort. Useful information turned up by a scientist in one field often has application in a totally unrelated field.

Twenty years ago there was little common ground for the Hall effect and electroluminescence. The Hall effect concerns magetic fields; electroluminescence concerns electric fields. Then came tremendous interest in a different field — semi-conductors—the half-insulator, half-conductor materials, such as silicon, germanium and various compounds. . . .

Information and development work in the field of semi-conductors has led to a greater understanding of both the Hall effect and electroluminescence. In fact the Hall effect now appears to have promise for practical application.

WESTINGHOUSE ENGINEER

Radio reception only during winter

The world does move. In the May 1922, Journal, A. S. Runciman A.M. E.I.C., writes "It is actually possible to set up in homes in Ontario and Quebec a simple receiving set which brings in the concerts from Pittsburgh and New York, not every night, but often during the winter." The quotation is lifted from Mr. Runciman's paper on "High Frequency Telephone as Applied to High Tension Power Lines," an excellent treatise on the fundamentals of radio communication, but rather belying its title, since it mentions the Shawinigan Water and Power Company's system only incidentally, saying ". . . if the weather looks bad at any of the stations, the battery switches are closed and the system is ready for instant use."

THE ENGINEERING JOURNAL

All at once?

64,000 mathematicians replaced by computor

—headline, MONTREAL GAZETTE

Too large for the living room

The worst snag in adopting the horn as a speaker loading device is the size required for fidelity of reproduction. The diameter of the mouth of the horn, for perfection, should equal the wavelength of the lowest frequency it is desired to reproduce. The wavelength of a 50-cycle note is 22½ feet. Moreover the rate of expansion from the throat (the narrow end) to the mouth, called the flaring constant, must conform to certain laws, so the length of our perfect horn for no cut-off at 50 cps would be about 70 feet.

In this imperfect world we can afford to make some compromise, but you can take it that a straight horn of proper design to reproduce down to 50 cps calls for a length of about 22 feet and a flare circumference of 24 feet and that is not a thing you can get into an ordinary living room.

H. A. HARTLEY, audio consultant

Safety should be built into plant design

Safety is not something to be attended to when we have time for it. Safety must be built into plant design. It must be taught to the new employee, before he starts, with the same thoroughness that he is taught to operate process equipment.

For the employee just to learn by experience is too expensive to life and limb—and to the company. We have found that the maintenance of safe working conditions in our plants is of benefit far beyond any resulting dollar saving—the human value, for want of a better term, being of the greatest importance to community and employee relations.

H. GREVILLE SMITH, president
Canadian Industries Ltd.

Management faces the "facts of life"

We hope to develop a real interchange of management techniques and information both ways across the Atlantic. U. S. managers are eager to learn from their counterparts in Europe.

The success of the American Management Association is evidence of the recognition by U. S. Industry of two "facts of life." The first is the willingness of U. S. executives at every level to exchange ideas and management techniques frankly and fully; the second is their recognition that the development of executives through scientific training in management must be accepted as a cost to the company.

DR. FREDERIC E. PAMP JR.
International Management Association

Automation — necessity for industry

Contrary to certain beliefs, automation is not a luxury: it is a means of producing at less cost. In the automobile industry, the margin of profit is less than 2% of the annual turnover.

Progress over the last 50 years in the field of mechanics provides us with interesting comparisons. In 1905, a French car with a crude body structure and the most elementary accessories cost 25,000 francs, (about 4,000,000 today). This luxury item of yesteryear gave its owner less real satisfaction (except perhaps where his pride was concerned!) than a mass-produced car which now costs under 500,000 francs.

FRENCH ECONOMIC AND TECHNICAL BULLETIN, Ottawa

Revolution in the TV industry

The television-set industry will be transformed into a more stable industry from manufacturers down to retailers as the result of an impending revolution that will affect virtually every phase of its operations.

Three recent incidents pointing to the industry's maturing viewpoint are:

One—for the first time this spring when inventories were mounting, maturity was shown in that manufacturers cut back their production until inventories reached a sensible level.

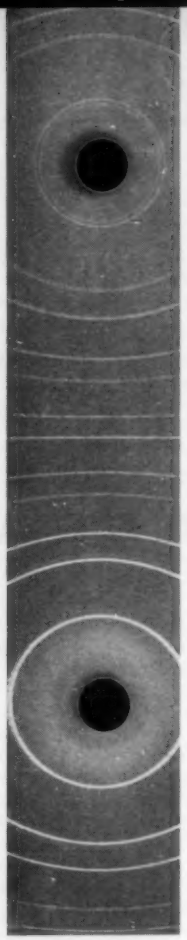
Two—maturity was shown by increased pricing which was more commensurate with the actual cost of producing television sets.

Three—maturity was shown by the industry's desire to market a new product which would offer obvious sell-up features and value to the consumer while offering higher unit sales and profit to the distribution chain. This new product is the 110-degree TV set.

MARION E. PETTEGREW,
Vice-President, operations,
Sylvania.

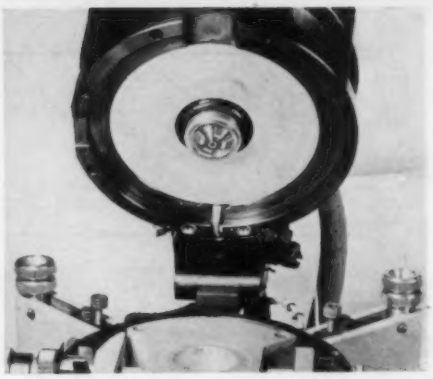
What's new in view

Round and round — electronics at work and play



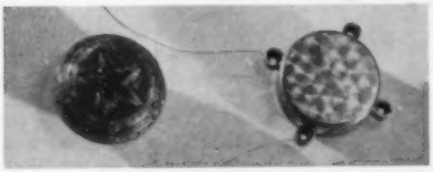
WHICH ORE?

Royal Ontario Museum use auto-radiograph to determine radio-active materials in ore. This is silicon



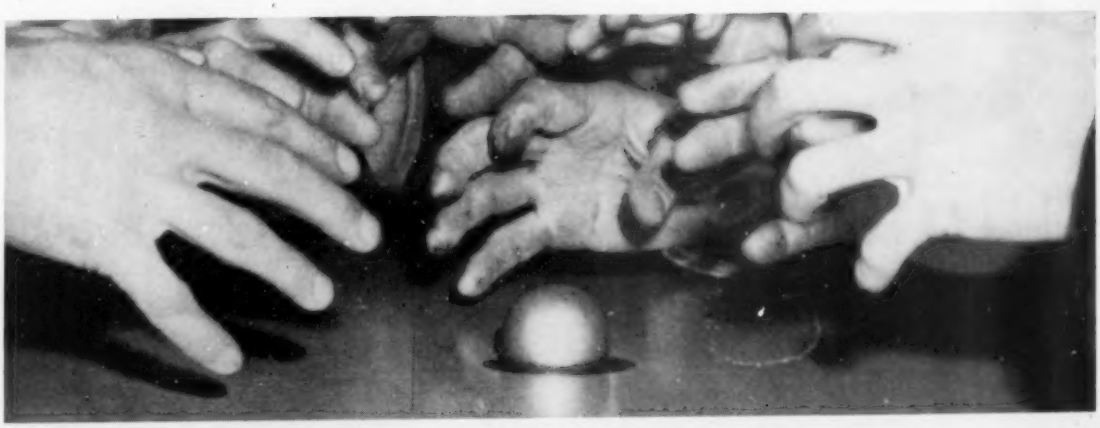
CLOSE-UP

Not a ten-ton press coming down but the latest Philips electron microscope being opened up. Microscope is hinged for easy cleaning

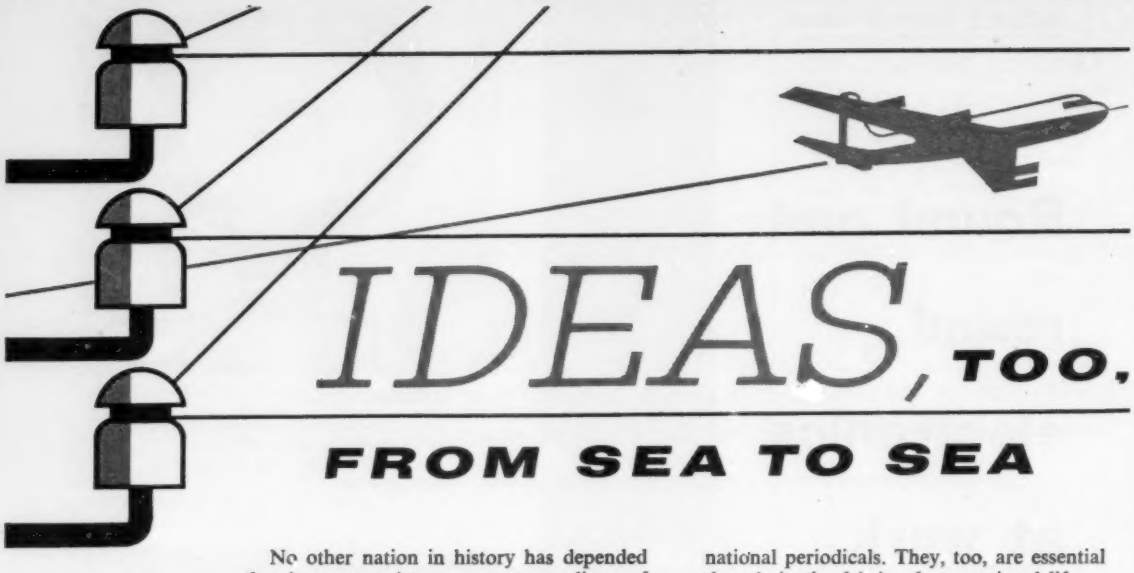


POWERFUL MIDGET

These two look alike but don't swallow the one on the right—it is Elgin's shielded nuclear battery which can deliver current for as long as five years. Predicted use is in transistor radios, hearing aids and wrist watches. On the left? Just a cough drop



PICTURE OF THE MONTH ▶ *You can even play games with electronics. This golden ball, at the London Exhibition "Electronics at work and play" was whisked out of reach before any of the grasping hands could get near it.*



IDEAS, TOO.

FROM SEA TO SEA

No other nation in history has depended for its very existence on strong lines of communications as has Canada. No nation has been better served by them.

Two railways, an air line, a pipe line, a highway, two telegraph systems and a waterway reaching from the Lakehead to the sea knit Canada together as a single unit. Communications are the basis on which Canadians have built their great commercial and industrial development.

But the communication of ideas is as vital to national growth as is the movement of goods and provision of services. That is the job being done by Canadian magazines and business papers. They serve all groups and areas in the country. The Massey Commission called them "our closest approximation to a national literature." In a young and widespread country like Canada you could not develop commerce or culture without national periodicals. They, too, are essential threads in the fabric of our national life.

As publisher of three magazines, four business newspapers and 31 other business publications, Maclean-Hunter Publishing Company is a part of this important group.

Through their news columns, Maclean-Hunter editors give national significance to many events that would otherwise receive only regional attention. They put national events in perspective that gives them new meaning to people of all regions. They comment vigorously on national issues, from a Canadian point of view.

All Maclean-Hunter editors are dedicated to the principles of accuracy, honesty and fairness. Together they provide unbiased news and sound opinion to more than 3,000,000 readers. We're glad that you are one of them.

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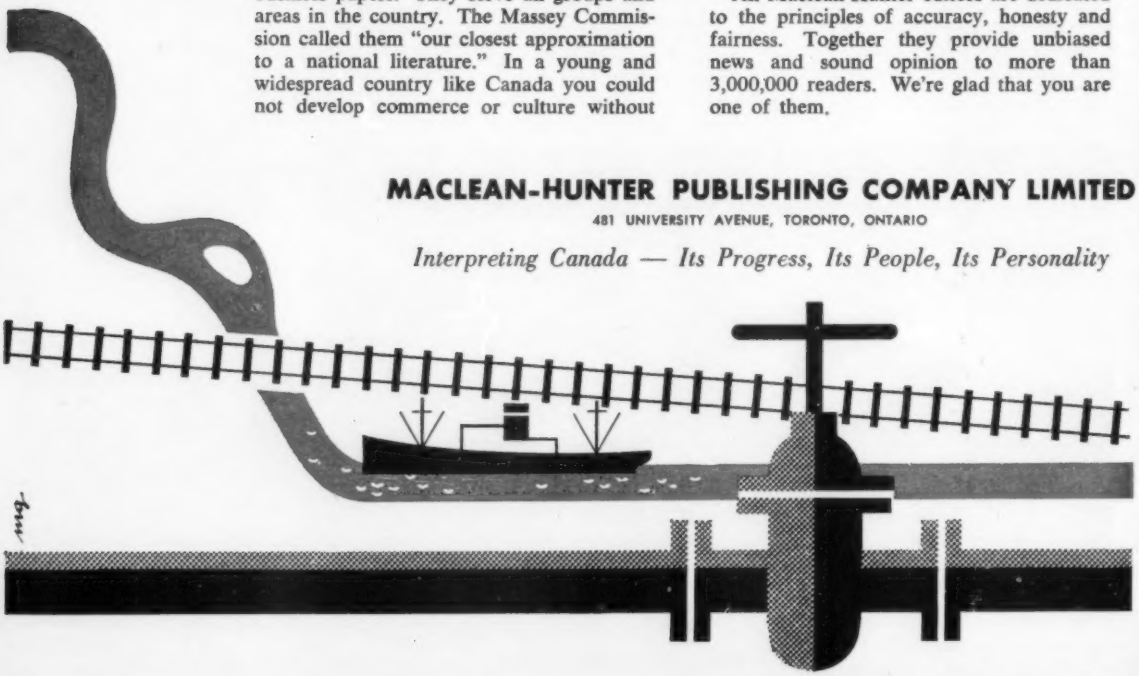
Interpreting Canada — Its Progress, Its People, Its Personality

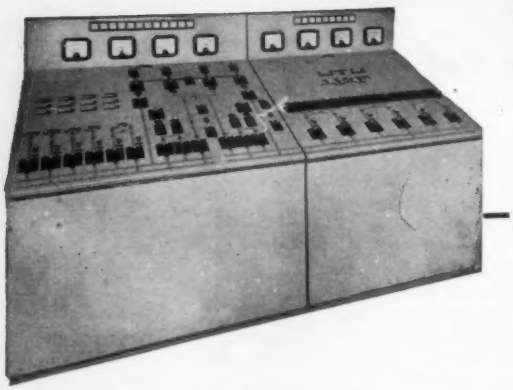


Exhibitors prepare for IRE Canadian Convention

Increased space at Toronto's Exhibition Park has been fully booked

Space for the IRE Canadian Convention, at the Exhibition Park, Toronto, Ontario, from October 16-18, has now been taken. The list of 145 exhibitors is as follows:

Ace Electronics Associates	Somerville, Mass.
Adams Engineering Limited	Montreal, Que.
Aeromotive Engineering Products	Montreal 29, Que.
Aerovox Canada Limited	Hamilton, Ont.
Aircraft Appliances & Equipment Limited	Toronto, Ont.
Aircraft-Marine Products of Canada Ltd.	Toronto, Ont.
Alford Manufacturing Company, Inc.	Boston, Mass.
Ampex Corporation	Redwood City, Calif.
Andrew Antenna Corporation Ltd.	Whitby, Ont.
S. A. Armstrong Limited	Toronto, Ont.
Assembly Products, Inc.	Chesterland, Ohio
Arco Electronics	New York, N.Y.
A. T. R. Armstrong Limited	Toronto, Ont.
Astral Electric Co. Ltd.	Toronto, Ont.
Atlas Radio Corporation Limited	Toronto, Ont.
Aviation Electric Limited	Montreal, Que.
Bach-Simpson Limited	London, Ont.
Bayly Engineering Limited	Ajax, Ont.
Beatty Bros. Limited	Fergus, Ont.
Behlman Engineering Company	Burbank, Calif.
Belden Manufacturing Co.	Chicago, Ill.
Benco Television Associates Ltd.	Toronto, Ont.
Berkeley Division, Beckman Instruments Inc.	Richmond, Calif.
Bishop Sons & Co. Ltd.	Toronto, Ont.
Bomac Laboratories Inc.	Beverly, Mass.
Burndy Canada Ltd.	Toronto, Ont.
The Burroughs Corporation	Plainfield, N.J.
Canada Wire & Cable Co. Ltd.	Toronto, Ont.
Canadian Admiral Corporation Ltd.	Port Credit, Ont.
Canadian Broadcasting Corporation	Toronto, Ont.
Canadian Electric Resistors Ltd.	Toronto, Ont.
Canadian General Electric Co. Ltd.	Toronto, Ont.
Canadian Marconi Company Ltd.	St. Laurent, Que.
Canadian Westinghouse Co. Ltd.	Hamilton, Ont.
Canadian Wilbur B. Driver Co. Ltd.	Toronto, Ont.
Cannon Electric (Canada) Limited	Toronto, Ont.
Capitol Radio Engineering Institute	Washington, D.C.
C. P. Clare & Co.	Chicago, Ill.
Collins Radio Company of Canada Ltd.	Toronto, Ont.
Computing Devices of Canada Ltd.	Ottawa, Ont.
Conrad, Inc.	Holland, Mich.
Dawe Instruments Limited	Ottawa, Ont.
Daystrom Limited	Toronto, Ont.
Decca Radar (Canada) Ltd.	Toronto, Ont.
Diamond State Fibre Company of Canada Ltd.	Toronto, Ont.
Dow Corning Silicones Limited	Downsview, Ont.
Eitel-McCullough, Inc.	San Bruno, Calif.
Electrodesign	Montreal, Que.
Electro-Measurements, Inc.	Portland, Ore.
Electromechanical Products	Agincourt, Ont.
Electronics and Communications (Age Publications Limited)	Toronto, Ont.
Electronics Engineering Maclean-Hunter Pub. Co. Ltd.	Toronto, Ont.
Electro Sonic Supply Co. Ltd.	Toronto, Ont.
Ericsson Telephone Sales of Canada Ltd.	Montreal, Que.
Erie Resistor of Canada Limited	Trenton, Ont.
Executone Communication Systems Limited	Toronto, Ont.
Ferranti Electric Limited	Toronto, Ont.
Filtron Co. Inc.	Long Island, N.Y.
Fleet Manufacturing Ltd.	Fort Erie, Ont.
General Communications Limited	Toronto, Ont.
General Instrument - F. W. Sickles of Canada Ltd.	Waterloo, Ont.
General Radio Company	Cambridge, Mass.
Glendon Company Limited, The	Toronto, Ont.
Hackbusch Electronics Limited	Toronto, Ont.
Hammond Manufacturing Co. Limited	Guelph, Ont.
Heinemann Electric Co.	Trenton, N.J.
Helipot Corporation	Newport Beach, Cal.
John Herring & Company Limited	Toronto, Ont.
Honeywell Controls Limited	Toronto, Ont.
Samuel C. Hooker (Canada) Limited	Montreal, Que.
The Hoover Co. Limited	Hamilton, Ont.
M. J. Howard & Company	Ottawa, Ont.
Huggins Laboratories Inc.	Menlo Park, Calif.
Hysol Canada Limited	Toronto, Ont.
The Indiana Steel Products Company of Canada Ltd.	Kitchener, Ont.
The Institute of Radio Engineers	New York, N.Y.
Instronics Limited	Stittsville, Ont.
International Electronic Research Corporation	Burbank, Calif.
The International Nickel Co. of Canada Ltd.	Toronto, Ont.
International Resistance Co. Ltd.	Toronto, Ont.
Kay Electric Company	Pine Brook, N.J.
George Kelk Limited	Willowdale, Ont.
Kester Solder Company of Canada Ltd.	Brantford, Ont.
Lake Engineering Co. Limited	Scarborough, Ont.
Leonard Electric Limited	Toronto, Ont.
E. G. Lomas Company	Ottawa, Ont.
McCurdy Radio Industries Limited	Toronto, Ont.
Marsland Engineering Limited	Kitchener, Ont.
Measurement Engineering Limited	Arnprior, Ont.
Measurements Corporation	Boonton, N.J.
Mechron Engineer Products, Ltd.	Ottawa, Ont.
Microwave Associates Inc.	Burlington, Mass.
Minnesota Mining & Mfg. Co. of Canada Ltd.	London, Ont.
Mycalex Corporation of America	Clifton, N.J.



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For your library

Geyger covers latest work on magnetic amplifiers

Magnetic Amplifier Circuits
Second Edition

Dr. William A. Geyger; McGraw-Hill Co. of Canada Ltd., Toronto; 394 pp; $8.40.

The first edition of this book has certainly come to be regarded as an essential reference work by those who are actively engaged in the field of magnetic amplifiers. However, as Dr. Geyger points out in the preface to this new edition, considerable development has taken place during the past five years, not only in a continuously widening range of industrial and military applications, but also in the devising of new magnetic amplifier circuits and in the addition of important advances in fundamental theory.

In the U. S. in particular, great progress has been achieved with regard to development of stable high speed magnetic amplifiers with response times of only one half cycle of the supply frequency, and the possibility of successful application of magnetic amplifiers in high-performance closed-loop servo systems has correspondingly increased.

Therefore, in preparing the present edition of "Magnetic Amplifier Circuits" three objectives have been kept in view: to give an account of this development, to expand considerations on the transient response of magnetic amplifiers, and to insert the respective references into their proper places in the text. The result has been a substantially enlarged volume containing a certain amount of new material which is presented here for the first time.

The method of presentation largely follows that of the first edition. However, the order and some details of presentation have been modified in a number of instances, in order more readily to include more developments and theoretical concepts. Among these, the treatment of "self-balancing" magnetic amplifiers, in which Dr. Geyger himself has been a pioneer, has been expanded in view of the increased growth and importance of this subject, particularly with regard to "operational-type" magnetic amplifiers for analog-computer systems and to low-drift high-speed magnetic servo amplifiers with two-phase motor load.

Dr. Geyger's wish that: "this edition will contribute even more knowledge about basic principles, characteristics, and applications of magnetic amplifiers to the many thousands of engineers, patent lawyers, teachers, students and newcomers who are interested in this special field of electrical engineering" will certainly be fulfilled. (560)

From microphone to ear

G. Slot, Philips Technical Library, 169 pp.

What is high-fidelity? Technically it can be pinned down to fairly close limits by standard frequency measurements at certain levels. But today high-fidelity is often claimed for equipment that reaches only medium standards and the average man-in-the-street is misled by all the conflicting statements.

It would be a good thing if that man-in-the-street could read this practical book. After a quick look at the acoustic period (Did Caruso really have to stick his head into a trumpet to record?), the book deals with recording techniques, the operating principles and characteristics of pick-ups, amplifiers and loudspeakers and the evaluation and testing of high-fidelity equipment. There is also a chapter on magnetic tape recordings.

If you have any friends, outside the electronics field, who have been bitten by the hi-fi bug, this is the book to recommend to them. (561)

Radio Telemetry

Myron N. Nichols & Lawrence L. Rauch. John Wiley & Sons Inc., New York. 461 p. $12.00.

In the rapidly developing field of radio telemetry this book is welcome for the comprehensive introduction it gives to the subject.

The book gathers together the basic theory and a cross-section of current practice in measurement and communication in radio telemetry. In addition it includes original contributions by the authors based on their experience gained in telemetering research and development.

The authors present background in environmental errors and inherent errors, frequency and time domain analysis, modulation and multiplexing, minimum signal strengths and thresholds, sampled data, smoothing and interpolation. On the basis of this background they analyze existing telemetry practices and equipment and compare them in terms of minimum required signal strength, cross-talk, susceptibility to environmental errors and information efficiency. (562)

Electrical Engineering Circuits

Hugh Hildreth Skilling. John Wiley & Sons Inc., New York, 724 p., $8.75.

After several years of classroom teaching, and repeated revision in response to student reaction, this new book on circuits is more than justified.

As a textbook it is designed for a full year's use. It gives students a strong foundation in the subject by devoting approximately two thirds of its coverage to traditional topics. Then it offers meaningful discussions of newer concepts, preparing students for advanced courses in electrical networks and system designs.

The new aspects of the book include analysis by Taylor's series applied to nonlinear elements such as vacuum tubes and transistors, introduction of the filter concept by way of transfer functions, discussion of active and reactive power and a chapter on the Fourier series leading to the Fourier integral and the Laplace transformation. (563)

Transistor Circuits
and Applications

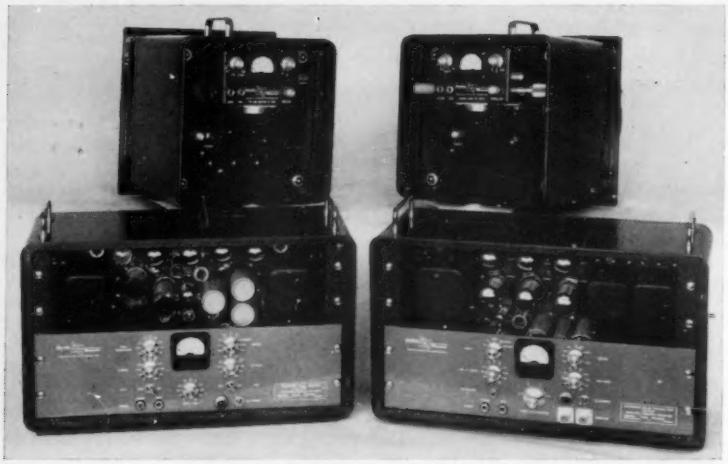
Edited by John M. Carroll; McGraw-Hill Co. of Canada Ltd., Toronto; 283 pp; $9.00.

This is a thorough treatment of the transistor art, including a large number of typical circuits with component values and explanatory articles which deal with transistor structures, techniques, circuits, and equipment. Compiled by one of the Associate Editors of "Electronics" magazine, the book comprises 106 feature technical articles that appeared in "Electronics" during the years 1950 to 1956.

All the basic amplifier, oscillator, pulse and switching circuits are shown with typical component values. The book furnishes characteristics of typical transistors, descriptions of basic types, important design considerations, and formulas. Many applications of transistors to home-entertainment, military, broadcasting, communications, computing, control, industrial, scientific, and medical equipment are described — with complete circuit schematics.

It is certain that this volume will be regarded as a valuable contribution to the ever-increasing area of semiconductor literature. (564)

Portable microwave relay system in four cases



American Microwave Corp. has announced their type MVT/MVR microwave relay system for common carrier television and data transmission usage. This equipment features interchangeable RF components for operation in the 6-7 KMc band (1 watt output) or the 11-13 KMc band (250 mw output). The system employs a receiver using a triode cascode IF amplifier with AGC action and AFC circuit, a tunable direct indicating wave meter, and full NTSC color transmission compatibility. The complete system is packaged in four "suitcase" type aluminum housings with weatherproofed RF head sections.

Pye Canada Ltd., Toronto. (565)

Key type selector switches

Thermo Electric (Canada) Ltd. has developed a new line of key-type selector switches. These provide users with a means of connecting sensing elements to indicators, recorders or other instruments.

Four-pole, double throw type key switches permit the optional connection of a number of sensing elements to either of two instruments. Double pole, single throw type key switches permit rapid checking of temperatures from many points or averaging temperatures from a number of sensing elements. Three-position key switches can be used to (1) connect many thermocouples or resistance bulbs to an indicator or recorder, or (2) transfer them from one instrument to another. Moisture-proof and dust-tight cases are suitable for flush panel or wall mounting. Case capacities range from 12 to 144 points for both thermocouples and resistance bulbs.

Thermo Electric (Canada) Ltd., Brampton, Ontario. (566)

For detecting leaks

To determine rapidly the location and size of leaks in such items as vacuum tubes, hermetically sealed components and glass-to-metal seals, a mass spectrometer leak test station has been introduced by Vesco. This is a complete self-contained mobile test station that does not require auxiliary roughing equipment.

The leak test station uses helium as the tracer and the sensing element is the Veeco Mass Spectrometer Tube capable of detecting one part of helium in ten million parts of air at 10^{-10} cc/second. The spectrometer tube is provided with its own pumps, vacuum gauges and electronics supplies. The "rough" pump system is a separate unit within the same cabinet and the automatic electrically operated valves are interlocked to protect all parts of the test system and to assure rapid, accurate testing on the production line.

Radionics Limited, Montreal. (567)

Five-inch flying spot scanner

A 5-inch flying spot scanner tube for use in television receiver test equipment has been developed and released by Sylvania Electric Products Inc. as part of its special purpose cathode ray tube program.

Designated type 5BNP16, the new tube employs low voltage electrostatic focus, an aluminized screen of very short persistence, and operates without ion trap for simplified installation. Compared to other tube types designed for studio flying spot scanning pickup equipment, the 5BNP16 is less expensive, approximately four inches shorter in over-all length, and operates at lower anode voltages.

Sylvania Electric Products Inc. (568)

Binary decoding C.R.T.

Development of a new cathode ray tube to help meet some of the complex problems of airport traffic control has been announced by Stromberg-Carlson. Designated the Indicoder the binary decoding tube will have a one-and-one-half inch square screen on which will be projected a numeral one inch high. When a group of such tubes is used in combination they will form an electronic display board.

The new system involves covering all characters in the matrix with a flood of electrons. All characters are formed simultaneously and the one desired passes through a single tiny aperture and reaches the phosphor-coated screen for display. The matrix for the Indicoder contains the stenciled numerals 0 through 9, a plus and a minus sign. This "flooding" principle eliminates one set of deflecting coils, permitting shortening of the entire cathode ray tube.

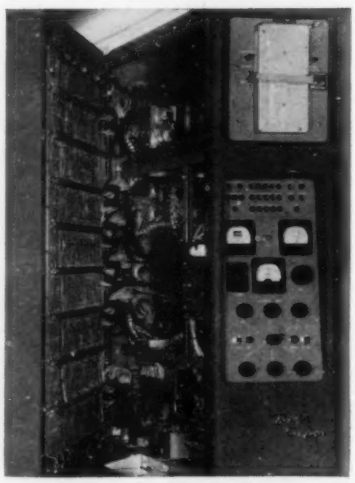
For special applications characters or symbols other than standard numerals may be substituted in the matrix.

Stromberg-Carlson. (569)

General purpose digital computer

The Bendix G-15D is a low cost general purpose digital computer especially adapted to engineering and scientific calculations. It weighs only 850 lb., with an additional 175 lb. for the optional magnetic tape unit.

Applications of the G-15D are diversified, including earth moving computations, training graduate university students in physics and mathematics, design and operation of electrical transmission lines and pipelines, "real time" data processing in aircraft and missile testing, and other work involving large amounts of repetitive calculations.



With the optional digital differential analyzer accessory, the G-15D becomes a powerful tool for solving problems in dynamic systems and automatic control.

The G-15D is sold and leased in Canada by Computing Devices of Canadad Ltd., Ottawa. (570)

(Continued on page 51)

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Transistors spur trend to portable radios

Two new products have been introduced by Electrohome—the Cavalier, a low-priced high fidelity phonograph and the C 66, a new 6 transistor portable radio.

The Cavalier, available in five Deilcraft finishes features a 5-tube high fidelity amplifier, twin 5 in. tweeters and a five-inch woofer in a solid wood cabinet. A British built changer offers both manual and automatic operation with four speeds. Other features include three-way record compensation, inputs for TV, tape, tuner or phono, separate base and treble tone controls and loudness control.

The C 66 (illustrated) is enclosed in a styrene plastic case with contour fitted metal carrying handle. The 6 transistor chassis allows operation for less than 1c an hour according to the manufacturer. Off-on volume and tuning controls are mounted on the top to allow operation from any angle. The rod antenna is built-in. Personal earphones are optional.

The entire unit measures 4⅞ in. high by 6¼ in. wide by 2¾ in. deep.

For complete details consult your nearest Electrohome dealer.

Dominion Electrohome Industries Ltd., Guelph. (571)

Portable radios use transistors

One AC-DC-battery model and two all-transistor battery sets have been added to the Canadian Admiral Corporation's portable radio line. All have unbreakable steel cases with leather grained vinyl fabric covering. Printed circuits have been used and the rotoscope antenna is designed to lock into the handle when the set is not in use.

The three-way portable contains five tubes and the battery is automatically disconnected when the plug is removed for insertion into AC or DC outlet.

The transistor portables, one using six transistors, the other using eight, are claimed to play up to 1,200 hours on eight ordinary flashlight D cells which deliver 12 volts. They measure 2½ in. deep by 9 7/16 in. wide and 8⅞ in. high.

Canadian Admiral Corp. Ltd. (572)

Fine pitch gear racks

PIC Design Corporation offers a range of precision, fine pitch gear racks available from stock.

These racks are available in the following A.G.M.A. Precision I pitches: 48, 64, 72, 96, and 120 pitch. They are made in #303 stainless steel and aluminum material.

Tecneek Associates, Montreal. (573)

Microwave pressure windows

A series of high power, broadband, flange-mounted waveguide pressure windows has been introduced by Microwave Associates, Inc. The windows provide a vacuum-tight seal and protection against humidity, dust, etc. and are used to seal waveguide and antenna systems, gas switching tubes, power tubes and ferrite components. The windows are available at frequencies from 2.45 to 75 KMC. These cover-flange-mounted designs are normally mounted between two choke flanges in waveguide assemblies. Windows are available for direct insertion into radar waveguide, or test bench applications in S, C, XL, X/2, X, Ke, Ku, K, Ka, and V band.

E. G. Lomas, Ottawa. (574)

Portable oscillator for 4.5 to 220 mc.

The Kay Electric Company announces the introduction of an oscillator with the following specifications: frequency range is 4.5 to 220 mcs., in six bands, direct reading, all fundamental frequencies. An AGC circuit provides a constant output voltage of 0.7 volts r.m.s. into nominal 75 ohms. An output meter and attenuators of 20, 20, 10, and 6 db fixed, plus a variable attenuator from 0 to 6 db, provide control of the output signal. Width 11 inches, depth 6½ inches, height 8½ inches, weight 19 pounds.

Measurement Engineering Ltd., Arnprior. (575)

Transistor-curve tracer

This instrument traces characteristic curves for both PNP and NPN transistors on the face of a cathode-ray tube. It has a 10-ampere collector supply and a 2.4-ampere base supply. Displays 4 to 12 curves per family, with input current

from 1 microamp-per-step to 200 milliamps-per-step, or input voltage from 0.01 to 0.2 volts-per-step. Vertical deflection is calibrated in collector current, base voltage, base current, and base source voltage. Horizontal deflection is calibrated in collector voltage, base voltage, base current, and base source voltage. Seven different transistor characteristics are plotted for examination and measurement; 16 dissipation-limiting resistances and 24 driving resistances are available. Single-family or repetitive display can be selected and transistor characteristics can be displayed in either the common-emitter or common-base configuration.

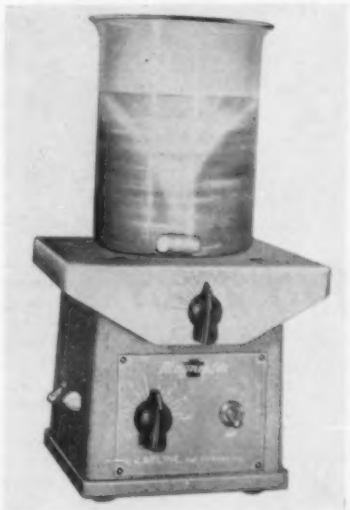
Tektronix, Inc. (576)

Heated magnetic stirrer

A new triple duty, 6 in. magnetic stirrer, which can serve as a hot plate only, magnetic stirrer only, or a combination of both, is available from Labline, Inc.

The Pyro-MagneStir consists of a die cast base enclosing a built-in motor, rheostat speed control for motor, switch for motor, a 6 in. square Aluminum hot plate with built-in thermostat, hot plate switch, and two (2) seamless Teflon covered stirring bars 1 in. and 1½ in. long.

Labline, Inc., Chicago. (577)

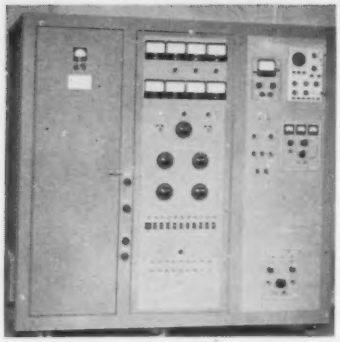


(Continued on page 52)

Pulsed power source tests L and S-band radar

Levinthal Model PC-52 pulsed power source utilizes both a Federal X-6825 traveling-wave tube and an Eimac X-551E klystron. Either L-band or S-band power is obtained by switching a common high voltage pulser to one tube or the other. The Federal tube produces up to 200 watts of pulse power over the band from 2.7 to 2.9 kmc. The Eimac tube produces 1.5 to 3 kw pulse power over the band from 1.25 to 1.365 kmc. Pulse lengths are variable from 2 to 10 mu at repetition rates from 200-450 pps.

System includes a built-in trigger generator capable of internal or external sync, a Maxson M1141 uhf power oscillator as the source of low level signal power, a Tektronix 315D oscilloscope for monitoring, a Hewlett-Packard 430C power bridge for power measurements,



both L-band and S-band directional couplers and transmission components, a high voltage pulser, solenoid power supplies and all necessary meters, controls, and protective devices. All necessary tuning controls are externally located.

Equipment requires about 4 kva of power from a 115-v, single-phase, 60-cps source.

Levinthal Electronic Products, Inc., Palo Alto, Calif. (578)

Hermetically sealed meters

Two groups of ruggedized, hermetically sealed moving coil meters have been introduced by WacLine Inc. These are the 2½ in. and 3½ in. ammeters and volt meters in a selection of ratings and dial shapes. Covers are assembled to housings by a twist lock system to facilitate servicing.

Radionics Limited, Montreal. (579)

Xenon filled thyratron

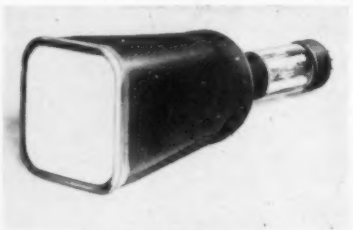
The Continental thyratron type XR-764 has the following specifications. Gas: xenon, base: octal with top cap, rating: 5 volts, 3 amps four filaments, 500 volts peak forward and reverse voltages, deionization time 200 microseconds.

Continental Electric Co., Chicago. (580)

Square faced CRT

The manufacturer claims that the 3½ in. square face design of the type 41HAP single gun electrostatic focus and deflection cathode ray tube provides a raster size almost as large as that of a 5 in. tube of round design. The angle alignment between the D1D2 and D3D4 traces is held to within 1 deg.; deflection factors are held to within 10% with low pattern distortion; grid cutoff bias is held to within 25%, according to the manufacturer. Over-all length is 11⅛ in.

Electronic Tube Corp., Philadelphia. (581)



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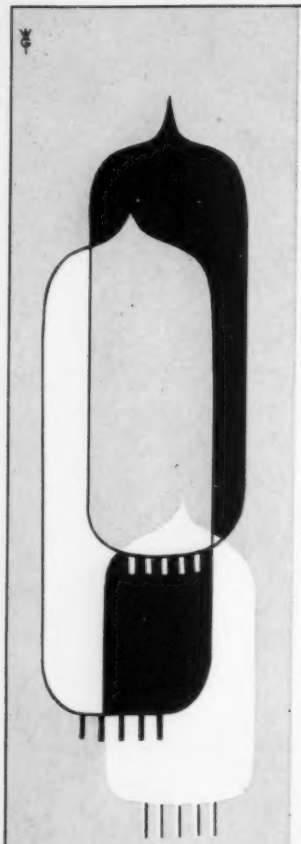

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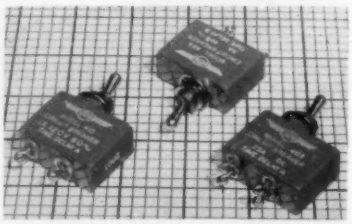
New products news

Shunt and relay circuit breakers

New shunt and relay style circuit breakers are available from Airpax Products Co. using the same magnetic time delay strip mechanism as the series style breakers. In shunt style breakers the release coil can be shunted externally; e.g. by a rheostat to adjust trip level. In relay style breakers the release coil is independent of the contacts.

Units are available with standard ratings to 10 amperes and contacts cannot be held closed manually in presence of overload. Two standard relays are available permitting normal starting in-rushes, operating surges and sequencing transients to pass without tripping the breaker.

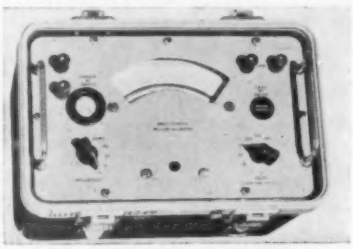
The circuit breakers are hermetically sealed and designed to withstand 50 g shock, vibration of 10 g to 1,000 cps and operate from —55 to +100 C (—67 to +212 F.). Contacts are rated for 50 v d c or 120 v RMS at 60 or 400 cps.



Airpax Products Co., Baltimore. (582)

Ruggedized reference standard meter

Diamond pivots and calibrated spring shock mounted saphire jewels have been used to produce a group of rugged, sensitive, direct reading instruments. Developed originally for an Armed Forces contract, these pivot assemblies are now being used on some of the manufacturers' commercial instruments.



One of these is the ruggedized, waterproof D.C. Polyranger built to the following specifications. Accuracy: 0.5% full scale on all ranges; Ranges: 0-1.5/5/30/150 mills, 0-0.3/3/15/30/150/-300/500 volts, (20,000 ohms per volt); Shielding: electrostatic and magnetic to A.S.A. specs.; Temperature compensated between ambients of 20 deg. C. and 30 deg C.; Double pivoted D'Arsonval movement with diamond pivots and shock mounted jewels; Fibre glass case with waterproof seal; Shock test: approximately 200 g's.

Measurement Engineering Ltd., Arnprior, Ont. (583)

(Continued on page 54)

Your Tektronix Field Engineer as a

MAINTENANCE AID

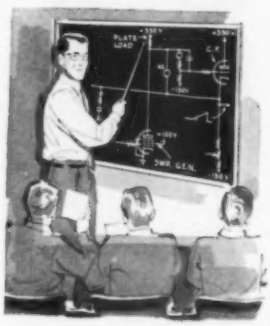
Lending a hand with maintenance problems is just one of his many helpful functions.

COMPONENT FAILURES

No matter how well designed and constructed, high-performance instruments are subject to component failures. Many such failures occur in vacuum tubes and are easily located and remedied by the instrument technician. But some troubles are difficult to locate, especially to those not yet thoroughly familiar with the circuitry. So in stubborn cases, call in your Tektronix Field Engineer. With his help you can quickly "put a finger" on the trouble source and get your instrument back to work with minimum delay.

MAINTENANCE INSTRUCTION

Instrument maintenance activities in large laboratories can benefit from the Field Engineer's thorough knowledge of Tektronix Oscilloscopes. He's available by appointment to conduct informal classes on maintenance, test and calibration procedures, and trouble-shooting techniques. And he's your best source of information on modification notes, kits, improved construction techniques and circuitry. He or his secretary can speed things up in an emergency by arranging prepaid air shipment from the factory on those replacement parts not normally stocked in Field Offices.



THE FIELD ENGINEER

Your Tektronix Field Engineer possesses the qualities that enable him to help you get the best possible return on your investment in Tektronix Oscilloscopes. He has been carefully selected, thoroughly trained, and, after actual experience in the field, established in your area to help you. You are entitled to his services. Why not take advantage of them?

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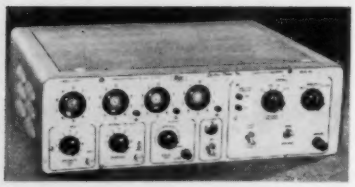
Frequency indicator with continuous recording



The Model 7341B frequency indicator with its associated desk model printer is designed for the measurement of frequency, velocity, rpm, etc. with continuous monitoring and printed readings. The unit counts events during the 0.1 second, 1 second or 10 second time bases available at rates up to 100,000 per sec. The measurement is then displayed on the low transfer counting tubes and may be recorded on the standard printer tape. Automatic re-cycle or single reading modes of operation are available.

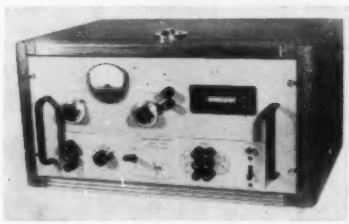
Self test for checking time bases and counters is provided and the unit may be used with an external time base. Input sensitivity is 50 millivolts allowing operation directly from common transducers.

Electropulse Inc., California. (584)

Millivolt relay programmer

A new program counter is available to turn on and off test apparatus whose limits are sensed by strain gauges, thermocouples or other transducers that have a maximum output of 100 millivolts dc. The Spar programmer counter is a millivolt relay having adjustable energizing and release thresholds and DPDT 15 amp contacts. The instrument, operating on 110 v a c has two adjustable thresholds for selection of upper and lower operating units. A counter registers each cycle.

Spar Engineering & Development Inc., Wincote, Pa. (585)



Subminiature relay

A new subminiature relay occupying only 0.18 cu. in. features ⅛ in. silver or palladium contacts capable of handling three amps resistive load or 4 amps intermittent. The basic design incorporates a permanent magnet in an electro-magnetic circuit and the relay is constructed with a balanced armature having no pivots, hinges or bearings. Three types are available: Model M-1000A is a dc spdt relay with standard pull-in at ½ watt. The standard coil is 24 volts at 550 ohms with special coils available up to 10,000 ohms.

Model M-1000AA is similar but with pull-in at ⅔ watt. Model M-100P is a two position dc polarized relay with sensitivities from 15 MW to 500 MW and two to three amperes contact rating.

Luther Manufacturing Co., North Hollywood, Calf. (586)

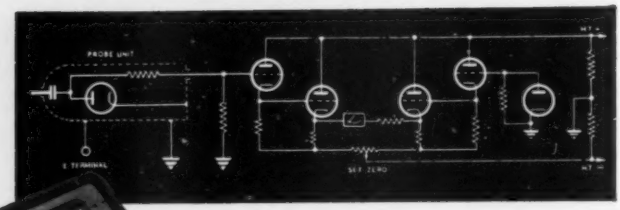
For detecting leaks

For detecting and locating leaks in vacuum or pressure systems the General Electric Model M-2 mass spectrometer has been introduced. The manufacturer claims this instrument is capable of detecting the leak rate of 1 x 10^{-10} standard cubic centimeters of air per second, with a response time as low as two seconds. The use of plug-in components on the electronic circuitry simplifies maintenance and operation.

Canadian General Electric Co., Ltd. (587)

(Continued on page 56)

Greater Accuracy



with

Marconi Vacuum Tube Voltmeter TF 1041

Accuracy

± 2% of full scale ± 0.01 volt
± 3% of full scale for inputs greater than 100 volts

Marconi's new vacuum tube voltmeter gives you these added advantages:

- *frequency response flat from 20 c/s to 700 Mc/s*
- *6 ranges for a.c. voltages — 0 to 300 volts*
- *7 ranges for d.c. voltages 0 — 1000 volts*
- *7 ranges for resistance between 0.2 ohm and 500 megohms*

Marconi Voltmeter TF 1041 has a large mirror scale meter for fast and precise reading. A specially designed probe makes point contact with the a.c. circuit under test. For d.c. potentials there are a movement-reversing switch and a three-lead rubber moulding fitted with either prods or alligator clips.

Marconi

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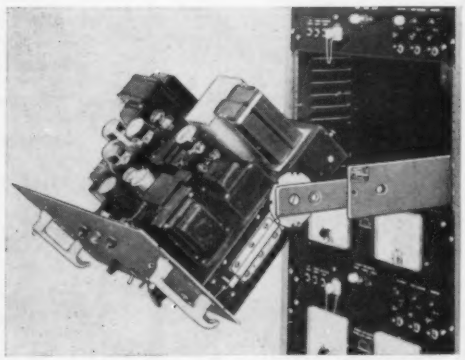
Cabinet slides hold chassis to aid servicing



Chassis-Trak cabinet slides permit chassis to be pulled out from cabinets and locked in position for servicing. "Basic" model allows chassis to be tilted freely without position locks while "Detent" locks in six positions — 45 deg., 90 deg. and 105 deg. up or down. Chassis can be completely removed. Fits 19 in. racks with other sizes and lengths available. (588)

Electrodesign, Montreal

Personal radio pager

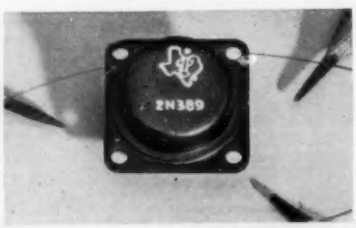
A radio paging system has been introduced by Stromberg-Carlson. The equipment consists of a transmitter encoder (usually located at the telephone switchboard) and a number of miniature receivers. When the operator selects the desired paging number on the encoder the receiver, carried by the called person, emits a humming tone which continues until turned off by a button on the receiver. In very noisy areas an ear piece can be worn to ensure that the calling tone will be heard.

Two systems are available. An industrial system provides up to 450 individually coded receivers and the transmitter provides coverage for a distance of ½ mile or more. The larger city-wide system provides for 3,235 individual codes.

Hackbusch Electronics Ltd., Toronto. (589)

High power gaseous transistors

Gaseous diffused-junction transistors are now commercially available from Texas Instruments. This high power silicon transistor has a rated power dissipation of 37.5 watts at 25 C and 15 watts at 100 C. With a 2 ampere collector current, the new 2N389 also features a maximum saturation resistance of only six ohms. When used in aircraft applications a 60-volt collector-to-emitter rating allows power to be taken directly from the 28 volt power supplies used by military aircraft.



The transistor has an operating temperature range from —65 C to +150 C and is projection welded in a metal case to meet the requirements of MIL-T-19500.

Texas Instruments Inc., Texas. (590)

High speed totalizing counters

The Computer-Measurement Corp. has announced a new series of direct reading, high speed electronic counters designed for industrial and special purpose counting. Any electrical, mechanical or optical event which can be converted into electrical impulses may be used to actuate the counter. Transducers to effect impulse conversion can be photocells, magnetic coils or switches.

Specifications include: Models, from 1 to 4 decades; count capacity; from 999,999 (Model 301A) to 999,999,999 (Model 304A); counts per second: ranging from 0-150 (301A) to 0-100,000 (304A); pulse pair resolution, 5 microseconds; input requirements, 0.05 volts dms.

Electromechanical Products, Agincourt, Ont. (591)

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Canadian Standards Association's annual meeting luncheon in Ottawa, left to right: Dr. W. P. Dobson (Ontario Hydro), D. D. Stewart (Atomic Energy of Canada Ltd.), J. S. Cameron, retiring president CSA, J. M. Thompson, Ferranti, who is the new president of CSA and Dean R. E. Jamieson, McGill University

Round-up

In four seconds computer will tell passengers if they have seats

Airline passengers can be told in a few seconds if seats are available on the date and flight they require by the first Availability Reservisor System in Canada, installed by Pan American World Airways. The equipment is in the Toronto office but will also be put into operation in Montreal and Vancouver. All offices in Canada and the U. S. are connected to the main availability board in Long Island City.

There the information is stored on availability panels, each panel containing 50 horizontal rows of jacks, with 35 jacks in each row.

The availability boards, or data processing equipment, are connected to the reservation agent's keysets by means of a multiconductor cable multiple. The agent sets are able to bid for access to the data processing equipment. When the bid is recognized, the input data from the agent set is processed, and the answer is returned to the agent set for temporary storage.

The agent set is released at this point from the data processor. The response is retained in the agent set until the agent interprets the resulting light pattern on the face of his set.

Dave Knudsen (standing) and Dave Underwood, Computing Devices of Canada Ltd, at the Canadian Aeronautical Institute Convention, Ottawa

Next month: How far can scatter go?

A tremendous amount of work is being done on scatter. Electronics Engineering of Canada will be taking a look at the latest developments in the August issue when there will be feature articles on various types of scatter and associated equipment, including the Canadian-produced Janet.

Among many feature articles are: "A P-N-P-N bistable element suitable for analog computers" by C. D. Florida and DRB and "Filament pulsing as a means of reducing power supply consumption of a vacuum tube" by D. Makow, S. Keays and S. Mak of NRC.

Next month, also, Electronics Engineering of Canada will publish the first of a series of articles on audio work. This one will deal with output transformerless amplifiers and their contribution to hi-fidelity production.

There will also be department news of people and the industry, new products and book reviews.

NUCLEAR POWER FIRST IN ONTARIO AND MARITIMES

In 20 to 30 years nuclear power will probably be necessary in Southern Ontario and the Maritime Provinces says D. D. Stewart, general superintendent, Reactor Operations Division, Atomic Energy of Canada Ltd.

Mr. Stewart was speaking at the annual meeting of the Canadian Standards Association in Ottawa. In Canada the total estimated commercial potential for hydro is 50 million kilowatts and only 33% over-all of that is being utilized. But the expansion of population and industry is taking place in regions where the utilization is higher—42% in Ontario and 27% in Quebec.

At 5.7%, its present rate of increase, Ontario would reach its limit of hydro power in 15 years and Quebec at 4.3% in 30 years.

The six new directors of CSA are: B. G. Ballard (NRC), B. F. Legget (NRC), T. A. Lindsay (Philips Electrical Industries Ltd.), R. H. Mather (Montreal), J. G. Morrow (Steel Co. of Canada Ltd.), L. B. Stirling (Shawinigan Water & Power Co.). Membership of the CSA is now 3,035.

COMING EVENTS

July

10-17 International Union of Crystallography, Fourth General Assembly and International Congress, McGill University.

August

20-23 Western Electronic Show & Convention, San Francisco.

September

3-14 International Union of Geodesy & Geophysics, eleventh general assembly. University of Toronto.

4-6 Magnetic Amplifiers Conference, Pittsburgh.

11-23 Radio, TV & Electronics exhibition, Paris.

24-25 Industrial Electronics Conference, Chicago.

October

7-9 National Electronics Conference, Chicago.

9-11 CEMA annual convention, Niagara Falls, Ont.

16-18 IRE Canadian convention and exposition, Toronto.

21-26 International conference on ultra high frequency circuits and antennae, Paris.

28-30 East coast aeronautical and navigational conference, Baltimore.

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